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Long-Term Prospects for Gold Mining

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Edited by
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and
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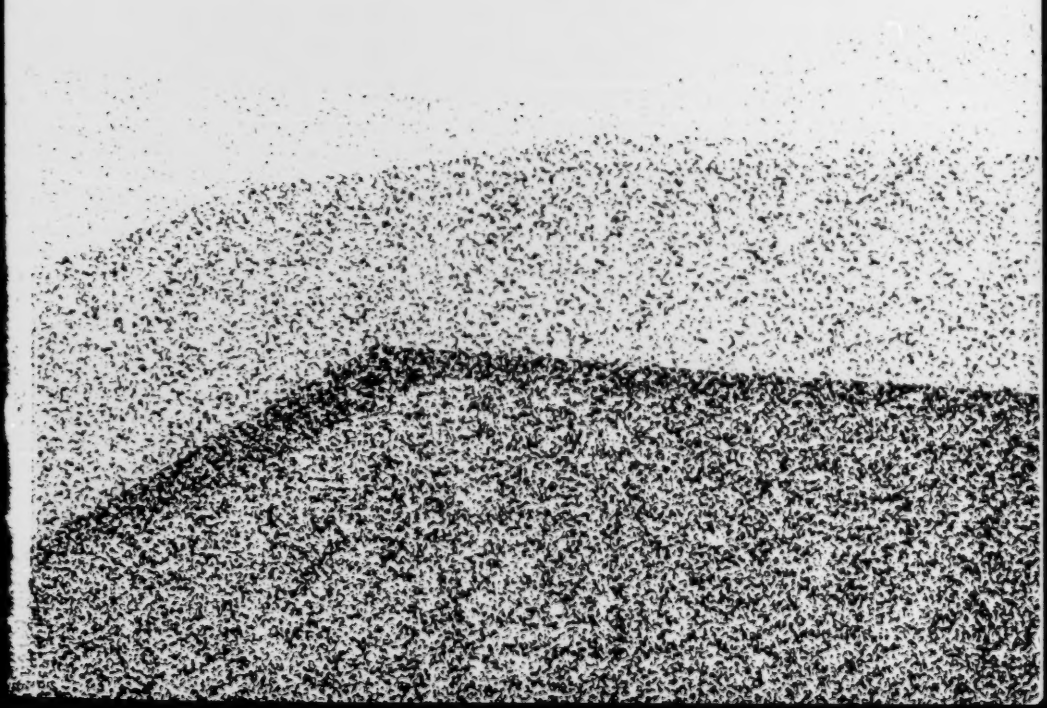

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LONG-TERM PROSPECTS FOR GOLD MINING

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FOREWORD

The spectacular rise in free market gold prices from 1970 has provided a worldwide stimulus for gold mining. Levels of investment in primary gold supply during the mid-1980s are unprecedented: $2-3 billion is being expended annually on exploration for economic gold deposits, tens of new gold mines are being developed to production, and billions of dollars are being invested in sustaining and expanding the capacity of currently operating gold mines. The relationship between these activities and the future price of gold, the main factor which will determine the economic viability of the investment taking place, is very unclear.

The policy workshop, convened in October 1986, examined the key determinants of the investment and growth in primary gold supply which is taking place. The purpose of the seminar was to discuss and define what we need to know to better understand the economic environment for gold mining and the justification for investment in gold exploration, development, and production which will prevail to the turn of the century and beyond. While relevant theory and analytical techniques were examined, emphasis was placed on applied empirical research to anticipate the future. As a basis for corporate planning and government policy, the primary focus was international supply-demand-price conditions, the minor theme being implications for Canada as a gold supplier.

The Centre is grateful for the contributions of the speakers, discussants, and other participants, both during the seminar and in the preparation of papers for the proceedings. Views expressed are those of individual participants and do not necessarily represent the views of the Centre or its sponsors.

Brian Mackenzie
Centre for Resource Studies

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A GOLD MARKET OVERVIEW: TRENDS IN SUPPLY AND DEMAND

Jeffrey Nichols

Until recently, the gold market has been characterized by a widespread and persistent view that gold has performed poorly as an investment asset. The yellow metal, however, has actually advanced in an intermittent and gradual fashion over the past year and a half. With gold recently trading in the $370 - $380 range, it has appreciated more than 30 percent from its low point near $280 an ounce in February 1985.

How has gold managed to do so well at a time of continued low inflation - and growing expectations of still lower inflation in the months and years ahead? How has the metal managed to advance in the face of such powerful competition from stocks and bonds, both of which have enjoyed bull markets of exceptional vigour virtually around the world? Why has the imagined link between petroleum and gold failed to bring the bullion price tumbling down with oil's fall from grace? And, how has the market been able to absorb an enormous increase in Soviet gold sales without disruption?

Seemingly, gold has done well against all odds. But in reality the market has been buoyed by its own bullish fundamentals - fundamentals which promise further gains during the years ahead.

A Matter of Supply and Demand

Analytically, our approach is to add up all of the sources of supply: mine production, secondary recovery of gold from old scrap, and sales by the Soviet Union and other centrally planned economies. From total supply we then subtract the quantity of metal consumed by jewelry manufacturers and other industrial users. After adjusting this remainder for net central bank sales or purchases, we are left with a surplus which must be taken up by investors for the market to balance, for total supply to equal total demand as it must. Table 1 summarizes recent trends in the major sectors of supply and demand and presents our projections for 1986.

Table 1

THE SUPPLY AND DEMAND FOR GOLD
(millions of ounces)

	1983	1984	1985	1986[a]
Mine production:				
South Africa	21.9	22.0	21.6	21.6
Other market economies	13.8	14.9	17.4	19.1
Total mine production	35.7	36.9	39.0	40.7
Secondary supply	11.5	10.5	9.5	8.5
Communist sales	3.0	4.0	10.0	11.0
Total supply	50.2	51.4	58.5	60.2
Industrial use	6.5	6.7	7.0	7.4
Jewelry	26.8	29.5	32.0	34.0
Total fabrication	33.3	36.2	39.0	41.4
Official purchases or sales (-)	-3.5	-2.0	3.0	4.5
Net private investment:				
Coinage	6.3	5.6	2.6	11.5[b]
Bullion	14.1	11.6	13.9	2.8
Total NPI	20.4	17.2	16.5	14.3
Total stock changes	16.9	15.2	19.5	18.8

Source: American Precious Metals Advisors, Inc., Summer 1986.

[a] APMA projections.
[b] Includes 9.4 million ounces for Japanese official coin program

Divergent Trends in Mine Production and Secondary Supply

Mine production has been expanding in recent years with all of the growth occurring outside South Africa. Thanks largely to the big step-up in the average prevailing price for gold between the past decade and the 1980s, as well as

to improvements in the art and science of mining that allow for the profitable exploitation of lower grade ores, the gold mining industry in North America, Australia, Brazil - and in virtually every country with exploitable resources - has been alive with exploration, the development of new mines, the expansion of existing ones, and, ultimately, with increasing production. Table 2 highlights mine production in key countries since 1979.

Table 2

GOLD MINE PRODUCTION, 1979-86
(millions of ounces)

	South Africa	Canada	U.S.	Others	Total
1979	22.6	1.6	1.0	5.5	30.7
1980	21.6	1.6	1.0	6.0	30.2
1981	21.1	1.7	1.4	6.7	30.9
1982	21.4	2.1	1.5	7.4	32.4
1983	21.9	2.4	2.0	9.4	35.7
1984	22.0	2.7	2.2	10.0	36.9
1985	21.6	2.8	2.5	12.1	39.0
1986a	21.6	3.2	2.9	13.0	40.7

Source: American Precious Metals Advisors, Inc.

[a] APMA projection.

The exception of course has been South Africa, where mining practices along with the depletion of higher grade deposits have moved the industry to lower and lower ore grades. Moreover, the growing unionization of the black mineworkers and increasing worker unrest has had its affect on South Africa's total gold output.

As a consequence of the trend in production outside South Africa, total mine output of gold in the market economy nations (those excluding the Communist Bloc) amounted to 39.0 million ounces in 1985, and growth this year should bring the total output up to 40.7 million ounces. This compares with an annual production of just over 30 million ounces in 1980, which is still below the record of 41 million ounces per year in 1965 and 1966.

Some bearish analysts of the gold scene have pointed to this truly remarkable expansion in primary output as a

force that will limit the market's future price. What they fail to realize is that mine supply is but one of several sources of the metal coming into the marketplace - and that changes on the demand side are just as important. For example, countering the trend in mine production has been a noticeable shrinkage in secondary supply, the flow of metal recovered from old industrial scrap and recycled jewelry. Secondary supply has diminished gradually in the past few years as a consequence of lower prices and the depletion of existing reservoirs of scrapable material. Compared with the record flow of over 21 million ounces of scrap in 1980 when prices were also at an all-time high, secondary supply last year came to roughly 9.5 million ounces. As can be seen in table 3, scrap may contribute only 8.5 million ounces to the market during all of 1986.

Table 3

MAJOR SOURCES OF GOLD SUPPLY
(millions of ounces)

	Mine Production	Secondary Supply	Communist Sales	Total Supply
1979	30.7	10.9	6.4	48.0
1980	30.2	21.2	2.9	54.3
1981	30.9	10.5	9.0	50.4
1982	32.4	11.1	6.5	50.0
1983	35.7	11.5	3.0	50.2
1984	36.9	10.5	4.0	51.4
1985	39.0	9.5	10.0	58.5
1986a	40.7	8.5	11.0	60.2

Source: American Precious Metals Advisors, Inc.

[a] APMA projections.

High Soviet Sales

If any sector of supply or demand has weighed heavily upon the gold market in 1985-86, it has been sales by the Soviet Union and other centrally planned nations. The bulk of these sales come from the Soviet Union, which according to some estimates, mines between 8 million and 10 million ounces a year, some portion of which is consumed domestically or in other Eastern Bloc nations. What we are concerned with is only their exports, that is their sales into

the free market. In addition to Russia, the People's Republic of China and North Korea also regularly sell small quantities from mine production, and other communist countries may at times sell (or buy) from official reserves. Bullion exports by the Communist Bloc probably equaled or exceeded 10 million ounces last year, compared with sales of about four million ounces in 1984 and three million ounces in 1983. And exports this year may equal or exceed even last year's lofty rate. Lower petroleum prices and production problems in Soviet oil fields are limiting foreign exchange earnings from that country's chief source of hard currency, just at a time when the pressures to modernize the Russian economy are requiring increased imports of high-tech and consumer goods from the West. Moreover, the nuclear disaster at Chernoble has led to expectations of continued high sales for the foreseeable future.

Only twice before have gold sales by the centrally planned economies exceeded ten million ounces per year: in 1963-65 sales averaged 13.3 million ounces per year for three years straight, and, in the three-year period 1976-78, sales again averaged just over 13 million ounces a year. The first episode occurred during the period of fixed gold prices, and the major central banks were obliged to absorb this increased supply of gold to keep the price steady at $35 per ounce. The second episode occurred at the time when gold was commencing its great bull market of 1976-1980 and was offset largely by rising investor interest and increased fabrication demand. That the Soviets once again have been able to so sharply boost their sales of this precious metal without any noticeable market disruption - and without any price setback - should be viewed as testimony to the inherent strength now building up within this market. In addition, it is believed that some of this year's gold sales by the Russians have been taken up directly by the Japanese government for the fabrication of coins.

Total supplies coming into the market hit a record 58.5 million ounces last year, reflecting these diverse trends in mine production, secondary supply, and sales by the centrally planned economies. This year supplies will be still higher, totaling 60.2 million ounces. But fabrication demand - consumption by jewelers, electronics manufacturing, dentistry and others - also has been expanding apace.

Fabrication Demand Continues to Recover

Although not yet exceeding the record 43.3 million ounces consumed in 1978, fabrication demand has been recovering

smartly from the depressed levels early in this decade when high prices and worldwide recession pushed offtake as low as 24.4 million ounces in 1980. As can be seen on table 4, last year's fabrication demand amounted to 39 million ounces and this year it should total 41.4 million ounces. Growth in jewelry and industrial demand will continue to reflect the improving business climate and personal incomes around the world, as the global economy benefits from lower oil prices and falling interest rates. Moreover, the depreciating dollar is lowering the price of gold and gold-containing products for many non-dollar consumers in Europe and the Far East.

Table 4

FABRICATION DEMAND
(millions of ounces)

	Jewelry	Electronics	Dentistry	Other	Total
1979	29.7	3.5	2.8	1.8	37.8
1980	17.8	3.2	2.0	1.4	24.4
1981	25.2	3.1	2.2	1.3	31.8
1982	29.0	3.0	2.0	1.2	35.2
1983	26.8	3.3	1.7	1.5	33.3
1984	29.5	3.7	1.8	1.2	36.2
1985	32.0	3.9	1.9	1.2	39.0
1986[a]	34.0	4.1	2.0	1.3	41.4

Source: American Precious Metals Advisors, Inc.

[a] APMA projections.

Central Banks Are Buying Again

While fabrication demand has been absorbing more gold, the official sector has also swung to the bullish side of the balance sheet as illustrated below by table 5. After a couple of years of net official sales, central banks as a group began buying gold again last year - and indications are that central banks are back in the market as buyers again in 1986. Net official purchases amounted to roughly three million ounces in 1985, and this year they could easily be in the four-to-five million ounce range. Ironically, among the biggest buyers in the past year have been countries like Brazil and the Philippines, which in 1982 and 1983

Table 5

NET CENTRAL BANK TRANSACTIONS

Year	Net Sales	Net Purchases
1979	-17.5	-
1980	-	+7.4
1981	-	+4.5
1982	-	+1.0
1983	-3.5	-
1984	-2.0	-
1985	-	+3.0
1986a	-	+4.5

Source: American Precious Metals Advisors, Inc.

[a] APMA projections.

were among the "distress" sellers, debtors scraping the bottom of their official reserves. These countries and a few others with domestic gold mining industries have made it a habit to buy locally produced gold, often paying a premium to the international price, but always paying in their local currencies, in order to build up their international reserve positions.

Perhaps indicating a new trend among the most hard-pressed, debt-ridden developing countries, Peru has recently been reducing its dollar-denominated official reserves in favour of gold. Press reports indicate that they "recently bought $200 million worth of gold (about 590,000 ounces) in world markets, apparently its third such purchase, as the financially beleaguered nation converts its hard currencies into the precious metal". What is more, they reportedly brought all of their gold and silver reserves back home to Lima to prevent foreign creditors from attempting to seize these assets. As the international debt crisis intensifies, it will be interesting to see if other nations follow Peru's lead and turn to the safety of gold. Finland, a non-debtor non-producer, has also bought some gold, simply to diversify its international reserve portfolio and reduce dollar exposure.

Sizing Up the Surplus

Adding up all of the sectors of supply, subtracting industrial and jewelry demand, and adjusting for net central

bank transactions, left roughly 16.5 million ounces to be taken up by investors in 1985. This is roughly 700,000 ounces less than investors actually purchased in 1984 on a net worldwide basis and about four million ounces less than investors purchased in 1983. Table 6 highlights the surplus taken up by investors each year since 1979. Looking ahead, the outlook for 1986 and beyond depends on two things: First, how big will be the surplus of metal to be absorbed by investors after accounting for the other sectors of supply and demand? And second, what will be the intensity of investor interest? Will environmental forces, especially the economy and international anxiety factors, encourage investors to want precisely this quantity of gold - or will they wish to add more or less to their holdings?

Table 6

THE SUPPLY/DEMAND BALANCE
(millions of ounces)

Year	Supply	Official Sales	Demand	Official Purchasing	Investors
1979	48.0	17.5	37.8	-	27.7
1980	54.3	-	24.3	7.4	22.6
1981	50.4	-	31.8	4.5	14.1
1982	50.0	-	35.1	1.0	13.9
1983	50.2	3.5	33.3	-	20.4
1984	51.4	2.0	36.2	-	17.2
1985	58.5	-	39.0	3.0	16.5
1986a	60.2	-	41.4	4.5	14.3

Source: American Precious Metals Advisors, Inc.

[a] APMA projections.

How does the gold market surplus look to shape up in 1986? Total supplies, as already noted, are likely to hit a record 60.2 million ounces this year. At the same time, fabrication demand of some 41.4 million ounces is projected while the official sector may purchase about 4.5 million ounces. Thus, the surplus left over for investors - indeed, which must be purchased by them for the market to be in equilibrium - will amount to only 14.3 million ounces this year. This compares to net investment offtake of 16.5 million ounces in 1985 and, importantly, represents a further tightening of the supply/demand balance.

To put the picture into perspective, should investors wish to purchase precisely the same quantity of gold this year as they actually bought last year, it would be impossible for them to do so. Something would have to give - and that something is the price. In order to balance, the market prices would rise to a point where additional supplies would be forthcoming, perhaps from an increased scrap flow, or fabrication demand would be reduced, or investor demand itself would be restrained, or, most probably, a combination of the above would occur until the price point at which total supply equals total demand.

The bottom line of this analysis suggests that supply/demand forces are mildly bullish for gold this year and, in the absence of any change in investor interest, the average price of this metal must be higher. But investors themselves are a fickle lot, and the intensity of their demand will be affected by a variety of international economic and political influences.

The Importance of Expanding Coin Sales

Another bullish development this year and next are the plans by several countries to introduce and market new gold coins. The Japanese, for example, plan to mint a commemorative coin honouring the 60th anniversary of Emperor Hirohito's reign. This coin will not be a "bullion" coin which sells at a small premium over its gold-content value like the Canadian Maple Leaf. Instead, it will sell at a premium of possibly more than 150 percent above its gold value. Hence, it will have little appeal outside Japan. Originally, the Japanese government planned to issue 10 million coins containing more than six million ounces - a sizable and significant quantity of metal in relation to the overall market situation. This summer, however, it appeared that the Japanese government was purchasing another three to six million ounces for an expansion of this program. (These latest purchases may explain much of the summer gold-price advance from the $340 an ounce area all the way up to near $400.)

The United States, meanwhile, is planning to issue its first legal-tender bullion coin in over half a century beginning this October, and there are also plans afoot in Australia, Luxembourg, and Brazil to introduce new coins. For the Australian and Brazilian coins, gold will be drawn from domestic mining industries, as has been the practice in Canada and South Africa, thereby depriving the world bullion market of these supplies.

As shown in table 7, the fabrication of official coins (and medallions) could consume in excess of 11 million ounces of the yellow metal during 1986. This compares with actual offtake by this sector of roughly 2.6 million ounces last year and 5.6 million ounces in 1984. There are two important points to make about this big step-up in coin production. First, there will undoubtedly be major marketing and advertising campaigns associated with these as well as with existing coin programs over the next few years. While these efforts will, no doubt, be product oriented, they will also have a generic impact - all of which should promote rising investor interest in gold more generally.

Table 7

GOLD INVESTMENT - COINS VS. BULLION
(millions of ounces)

	Coins	Bullion	Total
1979	10.4	17.3	27.7
1980	6.5	16.1	22.6
1981	7.0	7.1	14.1
1982	4.9	9.0	13.9
1983	6.3	14.1	20.4
1984	5.6	11.6	17.2
1985	2.6	13.9	16.5
1986[a]	11.5[b]	2.8	14.3

Source: American Precious Metals Advisors, Inc.

[a] APMA projections
[b] Includes 9.4 million ounces for Japanese official coin program.

Second, from a statistical point of view, the margin of metal left over in the form of bullion bars has already been sharply reduced largely as a consequence of Japanese official offtake. This bullion surplus may amount to only about three million ounces this year, roughly one fifth the quantity of bullion actually purchased by investors and added to their holdings in each of the past three years. Importantly, it is in the world bullion market where buyers and sellers come together and through their actions set the price. As this segment of the market tightens, as the supply of available bullion diminishes, the potential for larger price movements increases, as we have seen this last summer.

Summary - Main Points

How are the major sectors of supply and demand likely to shape up this year?

- Mine production in South Africa is holding steady and should amount to roughly 21.6 million ounces in 1986, about the same level as last year's output.

- Outside South Africa, mine production continues to rise. Output in the United States, Canada, Brazil, Australia and other market economy nations could total a record 19.1 million ounces this year, up 1.7 million ounces from 1985.

- Secondary supply is continuing to slide as low prices discourage recovery of old scrap and dishoarding of jewelry.

- Net sales by the Soviet Union and other centrally planned economies jumped sharply last year and remain at a fairly high level this year, a consequence of the Soviet Union's high foreign exchange requirements.

- Fabrication demand continues to recover smartly from the depressed levels early in the decade. At 41.4 million ounces, fabrication demand is at its highest level since the late 1970s.

- Central banks were buyers last year after two years of net sales, and current indications suggest the official sector could take some four-to-five million ounces during 1986.

- Several countries are planning to introduce and market new gold coins this year. Total gold coinage in 1986 could amount to a whooping 11.5 million ounces, reducing the available bullion surplus to a mere three million ounces.

- The surplus available to meet investment demand is continuing to shrink, providing some explanation for the relative strength in the metal's price, despite the hostile economic environment for hedge assets.

THE DEMAND FOR GOLD

Timothy Green

There has been a fundamental shift in the character of the demand for gold over the last twenty to thirty years. Historically gold was a monetary metal and its prime use was in gold coin and government gold reserves. Even the great flood of new gold supplies that suddenly became available after the California and Australian gold rushes in the mid-19th century was easily absorbed in under-pinning an expansion in world trade and triggered the switch from a silver standard, on which most of the world (except Britain) had operated, to a gold standard in the 1870s. It is an interesting reflection that from the 1870s silver became essentially a commodity, not a monetary metal, and its fortunes have depended on commercial demand ever since. Not so with gold, until much more recently.

Although the gold standard effectively ceased to operate in the early 1930s, the prime purchasers of newly mined gold remained central banks until the 1960s. Table 1 shows that although private purchases of gold for investment, jewelry and industrial purchases were growing during the 1950s, it was only by the mid-1960s that the private sector consistently became the major purchaser. If we consider the period from 1948 through 1964, 7,897 tonnes of gold were purchased by central banks and 10,150 tonnes by the private sector; central banks, in short, still took 43.7 percent of the gold. But if we take 1965 through 1985, what a different story! Central banks were actually net sellers of 2,256 tonnes into the private sector. Only in eight years out of the last 21 were central banks net purchasers. Given that the dollar's official link with gold was formally snapped in 1971, we must regard gold's future essentially as a commodity, not as a monetary metal. True it is a commodity with special attractions for the investor, but any mining company thinking ahead for the rest of this century and trying to project demand, must focus principally on the application of gold as a commodity and private investment vehicle, and not, as they might have done even twenty years ago (indeed as they were doing twenty years ago), as a monetary metal.

So gold's role as a commodity is new and is unprecedented in the long history of this precious metal. This is in direct contrast, for example, to platinum whose fortunes have always been founded on its industrial or jewelry

Table 1

GOLD BULLION SUPPLY TO THE NON-COMMUNIST PRIVATE SECTOR, 1948-85
(tonnes)

	Non-Communist World Mine Production	Net Trade with Communist Sector	Net Official Sales (+)	Net Official Purchases (-)	Total
1948	702	-	-	369	333
1949	733	-	-	396	337
1950	755	-	-	288	467
1951	733	-	-	235	498
1952	755	-	-	205	550
1953	755	67	-	404	418
1954	795	67	-	595	267
1955	835	67	-	591	311
1956	871	133	-	435	569
1957	906	231	-	614	523
1958	933	196	-	605	524
1959	1,000	266	-	671	595
1960	1,049	177	-	262	964
1961	1,080	266	-	538	808
1962	1,155	178	-	329	1,004
1963	1,204	489	-	729	964
1964	1,249	400	-	631	1,018
1965	1,280	355	-	196	1,439
1966	1,285	-67	40	-	1,258
1967	1,250	-5	1,404	-	2,649
1968	1,245	-29	620	-	1,836
1969	1,252	-15	-	90	1,147
1970	1,273	-3	-	236	1,034
1971	1,233	54	96	-	1,383
1972	1,177	213	-	151	1,239
1973	1,111	275	6	-	1,392
1974	996	220	20	-	1,236
1975	946	149	9	-	1,104
1976	964	412	58	-	1,434
1977	962	401	269	-	1,632
1978	972	410	362	-	1,744
1979	959	199	544	-	1,702
1980	954	90	-	230	814
1981	976	280	-	276	980
1982	1,025	203	-	85	1,143
1983	1,112	93	142	-	1,347
1984	1,149	205	85	-	1,439
1985	1,213	210	-	135	1,288

Source: Consolidated Gold Fields, Gold 1986, p. 14.

Note: Definition of official sales has been extended from 1974 to include activities of government-controlled investment and monetary agencies, in addition to central bank operations. This category also includes IMF disposals.

applications, and even on silver, which has had to make its way as a commodity now for well over 100 years. Gold, if you like, is still an infant as a commodity, still finding its feet.

When looking at what we know about the character of demand that has developed over the last twenty years, there are four key elements to be considered:

- the demand for fabrication in jewelry, industry and dentistry;
- the physical demand by investors for gold coins, medals, small bars and kilo bars, which they hold themselves;
- investment demand for gold held on metal account, in bank savings schemes for "loco London", where the client does not take physical delivery;
- central bank and government investment institutions, although, their role is diminished.

Additionally, of course, we have witnessed the growing impact of the markets for "paper gold" in futures and options. The volume of turnover on these markets vastly exceeds the normal physical market and can have tremendous impact on the price in the short term. But in the longer term, it is the day-to-day physical demand that must determine the price trend over periods of years. Paper gold markets cannot sustain the price forever if there is no genuine physical demand for the metal.

Among the above four key components, three can be monitored fairly accurately: fabrication, physical investment in coins and bars, and central banks. Investment demand on metal accounts and so forth cannot be monitored because this would involve banks and bullion dealers revealing confidential in-house information. This segment of demand, therefore, has always been essentially a residual figure once the physical demand is totaled up and netted off against supplies.

In the work that we have done at Consolidated Gold Fields over the last twenty years, we have always concentrated primarily on the offtake of newly mined gold, believing that this is most valuable for the mining industry. The scrap side has not been studied as thoroughly until the last few years. The figures quoted below relate to demand for newly mined gold (although there may be a very small scrap component in some fabrication figures for developed countries).

At the outset we should realize how price sensitive much of the physical demand is. There have been enor-

mous annual variations in demand, depending on the price. Both in 1974, when the price first went towards $200, and again in 1980 when it peaked at $850, the physical demand, especially for carat jewelry and physical investment in bars, shrank almost to nothing. New gold use in carat jewelry plunged from over 1,000 tonnes in 1977 and 1978 to a mere 128 tonnes in 1980, and, after that shock, has never fully recovered to its old level. Industrial/dental demand, by comparison, is much more stable.

This price sensitivity is particularly noticeable in what the Swiss used to call "traditional hoarding areas" of the Middle East, India, and South-East Asia. In these countries gold, either as jewelry or fake coins or bars, is the basic form of saving for millions of people in developing countries where banking systems, savings schemes and stock markets are not available (or not trusted) by most of the people, and where gold hoarding and exchange at marriages is still deeply interwoven into the social fabric of the country. Throughout the Arab world from Morocco to Saudi Arabia and in India, an exchange of gold at the marriage ceremony is still commonplace. And whereas a European or North American bride may get a 4 gram ring of 9 to 18 carat gold, in many Arab countries the bride may wear a 21 or 22 carat gold belt weighing from 200 or 300 grams to 2 or 3 kilos. But in these markets gold jewelry is purchased on very low markups of only 10 to 20 percent over the gold price of the day, compared to the 300 to 400 percent markups common in Europe and North America. Consequently, quite a modest rise in the gold price produces a profit on jewelry items in many developing countries, and many women will then trade in a few bangles, just as an investor here might take a profit on his shares on a stock market peak. Strictly speaking, therefore, we ought to regard this as "investment" jewelry, as opposed to decorative jewelry in developed countries.

The swift switch from heavy buying to heavy selling on price fluctuations in developing countries is a phenomenon only of the last twelve years. Historically the gold price was fixed; it did not fluctuate widely from day to day (though the exchange rate against gold in various countries obviously did vary). But until 1974 we had never seen widespread selling back of gold jewelry for profit (although there had been occasional selling in individual countries for distress reasons in famine or flood, as from India in the early 1930s).

I emphasize this price sensitivity, because in recent years it has led to extraordinary variations in demand, and this has had a crucial effect on price development.

The following geographic examples show the difference between developed and undeveloped countries. In 1977, 1978 and 1979, the fabrication of gold into jewelry in developed countries was between 550 and 600 tonnes annually, while in developing countries it was running at about 450 tonnes in 1977 and 1978, then fell to about 180 tonnes in 1979 as the price started moving up. In 1980 on the peak price, in developed countries jewelry still took 276 tonnes of new gold (i.e. it was down about 50 percent), while developing countries were net sellers back of scrap jewelry of nearly 150 tonnes. Moreover, these annual figures mask the amazing swiftness with which some regional markets, especially in the Middle East, can go into reverse, so to speak, overnight on a sudden rise or fall in the price.

Since 1982 I have been monitoring on a monthly basis a number of regional markets including Dubai (in the Arabian Gulf, which is the main supply centre for India), Singapore and Hong Kong. The monthly variations of their gold imports (or exports) related to the gold price are instructive, and are becoming extremely valuable in judging when the gold price is either realistically based or in speculative territory. In the first half of 1982, for instance, when gold was drifting down from just under $400 towards $300, the combined imports of Dubai, Hong Kong and Singapore rose from 32 tonnes in January to 49 tonnes by mid-year, when the price was lowest. Then when the price suddenly shot to over $400 (and briefly to $500) in the early autumn of 1982, demand in those three centres evaporated and they started shipping back. In September 1982, over 6 tonnes came back. In other words, they switched, almost overnight, from taking gold at an annual rate of nearly 500 tonnes, to supplying it back to the market at an annual rate of perhaps 60 tonnes - the equivalence of first taking most of the South African production, then overnight becoming suppliers of the amount of gold produced in Canada. Such a reversal underlines how a rapid price shift switches the onus to investors/speculators.

In fact, after the reversal in the fall of 1982, there was no positive offtake in the Dubai, Hong Kong and Singapore markets for over eight months, and only when gold came back under $400 in October 1983 did they again start to import substantial amounts of gold (25 tonnes that October). Throughout 1984 and into early 1985, as the price drifted on down to $300 and below, the offtake through these three markets grew continuously. In January 1985, with an average gold price of $302.82, their offtake was 59 tonnes (more than all South African

production), and in the first three months of 1985 they absorbed over 170 tonnes of gold, or 56 percent of western mine production in that period. But when the price went up in late March 1985 to around $340, the monthly imports fell away to 20-25 tonnes (a fall of over 50 percent) and have never really recovered since, staying in that range until August 1986 when the price run towards $400 virtually killed all demand. We do not yet have complete figures for August, but my estimate is a net offtake of about 3-5 tonnes at the most for the three markets. In September 1986, with a price of over $400, both Singapore and Hong Kong were shipping gold back to Europe, probably at a rate of 10 to 15 tonnes a month.

That volatility in demand in three important centres is mirrored in world markets as a whole (though less dramatically in most other centres). Since 1983 I have attempted to monitor worldwide physical offtake each month and hope to publish the full details next year.

In January and February 1983, the price of gold was close to $500. In those two months, the net worldwide physical offtake for fabrication, coin, and bar hoarding was a mere 30 to 35 tonnes. Taking into account that western mine supply then amounted to about 95 tonnes a month, while Russian and other sales usually amounted to about 120 tonnes in all, you see at once that at $500 the investors/speculators had to carry the load. Only in October 1983, when gold slipped under $400, did the worldwide physical demand move up over 100 tonnes monthly, and stayed there through 1984 with gold drifting down towards $300. By January 1985, with gold hovering around $300, this worldwide demand had shot up to around 160 tonnes monthly - substantially more than conventional new supplies to the market. Not surprisingly, the price went up. Worldwide demand then fell back instantly to about 100 tonnes a month, and the price had no momentum for the rest of 1985.

However 1986 is a different story. The truly exceptional demand for Japan in the first half of 1986 meant that monthly worldwide offtake soared as never before. Japan alone took up more than all South African production for the first seven months of 1986 (an event without precedent). Consequently world demand was 131 tonnes in April, 177 tonnes in May, and 200 tonnes in June (these figures are for deliveries, not necessarily purchases in those months, but they show the high level of demand in the period). Taking the three months together, worldwide physical demand was over 500 tonnes - an amount equal to an annual rate of 2,000 tonnes. We estimate that for 1986,

supplies to the market will be about 1,600-1,650 tonnes. Measurable physical demand alone, therefore, was easily exceeding supply. Not surprisingly, the price went up. In August/September 1986, however, demand plummeted. I estimate that for September we are back to a demand level of about 70 tonnes physical offtake. That is much less than new supplies. But sentiment had changed and investors/speculators are shouldering the burden. We were back in speculative price territory, with the "bread-and-butter" demand for gold running well below supplies.

These fluctuations in demand are crucial. In most other commodities, the character of demand does not fluctuate nearly so widely from month to month. Any understanding of the long-term price potential for gold can only begin with the realization of how volatile demand is.

First, jewelry, which is absolutely the cornerstone of the gold market, has replaced the central bank/monetary role. Although this demand fluctuates, there is no substitute. In the years 1968-1985, covered by Consolidated Gold Fields research, 13,635 tonnes of gold had been fabricated into carat jewelry, out of 23,894 tonnes available to the private sector (that is with central bank purchases/sales netted off). Thus, jewelry accounted for 57 percent of all gold demand over the last 18 years, and if the years 1974 and 1980, when high prices eclipsed jewelry, are taken out, the share comes up to almost 61 percent.

Thus, in the new era of gold since its monetary use declined, jewelry has become the absolute cornerstone of the market, year in, year out.

But there is a warning sign which must be considered when thinking of the long-term outlook for gold. In the 1980s, western gold mine production has risen fast but jewelry demand has not risen in tandem. If we look at the six years from 1980 to 1985, jewelry absorbed only 53.8 percent of the gold coming to the private sector. On the other hand, it was up to 70 percent in 1985 - a year of the lowest average price since 1979. Jewelry apparently can still hold its own in price troughs, and indeed, demand picks up sharply to cushion further price falls. Jewelry is the safety net for the price; it is certainly not the catalyst that can push it up. The moral is that the larger the jewelry demand, the higher the safety net. Consequently, as gold mine output rises for the rest of this decade, the target must be to maintain the jewelry demand at close to 60 percent over a period of years. It had been pushed to 900 to 1,000 tonnes a year on average - and that is better than it has been doing in the 1980s. The mining industry there-

fore must question how jewelry demand can be maintained and expanded.

The industrial/dental demand for gold by comparison is relatively static and usually fluctuates between 200 to 230 tonnes a year. In the industrial sector, dominated by electronics use in Japan, the U.S. and West Germany, there are some annual fluctuations depending on the health of the electronics industry. There have also been great improvements in using thinner plating solutions and in miniaturization, but, although gold use on a printed circuit or semiconductor may be less, the vast increase in the units produced is maintaining a fairly steady level of gold use. There is a modest decline in the dental sector, because governments are less and less inclined to pay for dental gold work out of social security benefits, but dental demand will probably stabilize at about 50 tonnes annually. Looking ahead, we may project that industrial/dental demand will stay at 200 to 230 tonnes, 14 to 15 percent of demand, for much of this century.

Taken with jewelry, this means that fabrication can absorb 70-75 percent of the gold likely to reach the market. Thus fabrication in jewelry, industry and dentistry is the real basis of the gold market.

Now what about coins, medals and small bars (i.e. those of 50 grams or less)? The introduction of the Krugerrand in the early 1970s, and later of the Maple Leaf, the Australian nugget and now the prospect of the American Eagle and various other coins, has opened up a whole new investment sector for the individual investor (especially in Europe and North America) who can afford only an ounce or two of gold. Similarly small bars have fulfilled this role in the Middle East and Singapore. In the ten years from 1976 to 1985, about 2,400 tonnes of gold went into coins, medals and small bars - 17.7 percent of the private sector supply.

Although demand was particularly high in 1978 and 1979 (the best years for the Kruger), a regular offtake of about 100-150 tonnes can be foreseen, and in 1986, because of the Japanese Hirohito coin using over 200 tonnes, this will be far exceeded. Indeed in 1986 with the Hirohito coin and the American Eagle launch, coin demand alone will be easily over 300 tonnes. If the Japanese repeat their coin program next year and the Eagle does well, then we could again be over 200 tonnes. The Australians also have ambitious plans for their nugget. Thus the coin sector, in particular, has good prospects in the next year or two. But the demand here will depend much more on investor sentiment for gold and will fluctuate.

So too, does the demand for larger bars - usually kilo bars, ten tola bars (3.75 ounces) or bars locally made in such places as Hong Kong, Bangkok and Indonesia. At Gold Fields we have always had a table called Identified Investment holdings (sometimes called bar hoarding) which may mystify some people. Essentially it means specific purchases of gold for investment by individuals for keeping in their homes or safe deposits. For example, in Japan for the last two or three years there have been very substantial purchases of bars by wealthy individuals.

We estimate 105 tonnes in 1984 and 115 tonnes in 1985, and perhaps it will be 200 tonnes this year (with a very low yen price). We can monitor this because the gold is imported into Japan and sold through bullion dealers, who report to the government. Similarly we can judge bar hoarding of gold that actually moves into countries like Indonesia or Taiwan. We know, for instance, 80 tonnes went into Taiwan last year, and only about 30 tonnes of this was for jewelry; the balance is bar hoarding. But we cannot get similar information in such detail in Switzerland, London, Toronto or New York, although obviously there are purchases in all those places for individual hoarding (though rather more on metal account). So when we say that in 1985, 308 tonnes of gold went into identified investment holdings, we are counting only the Middle East, India and the Far East, including Japan. Gold bars are an important component of demand - especially in years of low prices. In the ten years from 1976 to 1985, about 1,860 tonnes of bars went into physical investment holdings - nearly 14 percent of all private sector supplies.

Let's review the main components of demand we can monitor. Their importance on average over long periods is:

Jewelry	57 percent
Industry/dental	14-15 percent
Coins, metals, small bars	17.7 percent
Identified hoarding	14 percent

(This comes to more than 100 percent simply because of annual variations within each segment).

Additionally, of course, there are the "unidentified investors" buying on metal account or loco London, futures market stocks, etc. This is the residual in the Gold Fields survey. In fact, over the long haul of 1968 to 1985, the net amount is only 792 tonnes or 3.6 percent of demand on average over that period. But again there are wide variations. The interesting point is that most of these positions were built up in 1968 (when gold broke out of $35)

and in 1973 and 1974, when the price first really took off from the $40 level towards $200. Since then only in 1979 and 1980, and in 1983, have substantial "unidentified" investment positions been built up. And in fact since 1980 there has been net selling by these unidentified investors every year except 1983. Overall investment positions have declined by over 400 tonnes in the 1980s. In short, investors have been net sellers in this decade, which is, of course, entirely in keeping with the mood of the market. Sentiment has been against gold investment; high interest rates, a strong dollar, good stock and bond markets have all been better attractions in recent years.

The investor/speculator in certain moments is, of course, the catalyst pushing up the price in the short term. But a longer-term appraisal of the scene shows only too clearly that over many years he is not really an important net absorber of the metal. This underlines that the onus is on regular demand for jewelry, industry, dentistry, and the physical investment offtake of coins and bars. Year in,year out, that is the basis of this market nowadays. Any mining company now busily burrowing out a lot of this new gold production and talking (as some do) rather airily about "investors" taking up gold, ought to think rather carefully: "Who are these investors? And mining companies ought to see that the long-term future of the metal is really in the hands of its physical users around the world - whether they give it to their daughter in marriage or tuck it under their bed. Of course this is semantics, but you can call it investment too - and so it is. Gold has a traditional reputation as a store of value, which is its prime attraction even as jewelry.

Finally, let me conclude, as I began, with central banks. Over the last twenty years they have been net sellers. But the selling was primarily U.S. Treasury and International Monetary Fund stocks in the 1970s. In the 1980s, the central banks have actually been net buyers of nearly 500 tonnes (about 7 percent of supplies). The main buyers were initially OPEC countries diversifying their reserves, and in the last two years producer countries like Brazil, Colombia and the Philippines stock-piling some of their domestic gold output.

We have also witnessed recently Peru buying gold and taking it home to avoid asset seizure. But essentially these are all special cases. Moreover, OPEC has ceased to be a buyer, with the collapse of oil prices, and Brazil, Colombia and the Philippines must all be regarded as rather weak holders who might sell into any strong price rally. Peru also might eventually be forced to sell. So, looking ahead,

the central bank contribution is likely to remain very modest as a component of demand; some years they may be net buyers, in others, when countries are trapped by debt problems, they will be sellers. Certainly they cannot be counted on as a reliable cornerstone of the gold market.

The message, therefore, must be that the future of gold is as a commodity with special appeal to private investors. And what is going to be needed, as gold production continues to increase, are radical initiatives to step up the physical demand, especially in jewelry, and perhaps coins and small bars. The Kruger was one such initiative in the early 1970s that opened up a whole new segment of the market. For the late 1980s and 1990s, we are going to need more bold plans if mining companies want to see a real increase in the price of gold.

MINE GOLD SUPPLY TO THE YEAR 2000[1]

Jim Fisher

Introduction

The world's gold mining industry is in the throes of structural change. Production of the yellow metal in all the major gold producing countries except South Africa has been increasing rapidly during the past five years, whereas South African production has seemed to stagnate. This paper seeks to identify the underlying forces at work, to develop an understanding of the factors which will affect gold supply to the year 2000, and finally to present some tentative supply forecasts.

The Gold Mining Business, an Analysis of the Recent Past

The Western World Outside South Africa

The gold mining business changed fundamentally in 1971, when the United States finally abandoned the gold standard. Prior to 1971, the gold price in real money terms had declined steadily for many years; for example from 1950 to 1970, maintenance of a fixed dollar price for the metal meant that it's real value almost halved. However, during the five years to 1975 the real money value trebled, and although subsequently there have been wide fluctuations, the low metal values of the 1950s and 1960s are clearly a thing of the past.

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1. Brook Hunt & Associates Limited believe the contents of this paper to be accurate and reliable, and care has been taken in its preparation. However, Brook Hunt & Associates, its officers and employees cannot accept any responsibility, financial or otherwise, for any data presented nor any consequences arising out of the use of this paper.

Table 1

THE LONDON GOLD PRICE 1950-85
(average; U.S.$/troy ounce)

	Money of the Day ($/oz)	Constant 1985 Dollars ($/oz)
1950	35	188
1955	35	158
1960	35	134
1965	35	118
1970	35	99
1975	161	320
1980	612	793
1981	460	541
1982	377	419
1983	424	456
1984	360	375
1985	313	313

This change in the value of gold (table 1) since the early 1970s may be contrasted with the lacklustre performance of virtually all base metals over the same period. Copper and zinc are two examples (see table 2).

The sharp increase in real gold prices from 1971 onwards has led to an order of magnitude reevaluation of the place of gold in the portfolio of mining companies' operations, to the point where gold is now the principal target of almost all metal exploration programs. We estimate that in 1984, gold exploration accounted for some $600 million, out of a total Western World exploration expenditure on mineral commodities (excluding oil) of about $1.1 billion, a share that is still on the increase.

The growth in gold exploration, however, lagged for some time behind the rise in the metal price. In 1980, six years after the threefold rise in real gold prices, expenditure on gold exploration accounted for $300-400 million, out of a total of some $1.8 billion. In 1975 gold probably accounted for some 10 percent of exploration program budgets; in 1970, outside South Africa, it had been negligible.

As the rise in exploration lagged behind the gold price increase, so there has also been a significant lag in the resultant commissioning of new gold mining operations. This is clearly illustrated in table 3 which shows gold production in the Western World outside South Africa for the past fifteen years. (South Africa is clearly a special case which is evaluated later in this paper.)

Table 2

AVERAGE ANNUAL LME COPPER AND ZINC PRICES 1950-85

	LME Copper Price		LME Zinc Price	
	Money of the Day (US c/lb)	Constant 1985 (US c/lb)	Money of the Day (US c/lb)	Constant 1985 (US c/lb)
1950	22.4	117.3	15.2	79.6
1955	43.8	193.0	11.5	50.7
1960	30.8	114.9	11.4	42.5
1965	58.5	193.1	14.3	47.2
1970	64.1	176.6	13.4	36.9
1975	56.1	111.5	33.8	67.2
1980	99.3	128.8	34.5	44.7
1981	79.6	93.7	39.1	46.0
1982	67.2	74.6	33.8	37.5
1983	72.2	77.7	34.8	37.5
1984	62.5	65.0	40.4	42.0
1985	64.9	64.9	34.9	34.9

Table 3

MINE GOLD PRODUCTION IN THE WESTERN WORLD OUTSIDE SOUTH AFRICA 1970-85
(tonnes)

1970	273.2
1971	259.3
1972	274.0
1973	265.7
1974	248.0
1975	232.3
1976	250.3
1977	262.4
1978	265.5
1979	253.9
1980	279.3
1981	318.6
1982	360.4
1983	432.1
1984	465.6
1985	539.5

Source: Consolidated Gold Fields.

It might be argued that without the price increase there would have been a continuing decrease in gold production from 1971. However, the lag of nine years between the change in metal price structure in 1971 and its resulting effect on new mine production from 1980 onwards (as shown in figure 1) is of the right order: 2-5 years for mining companies to be convinced of the real change in metal values, and to change exploration priorities; 3.5 years to find and evaluate a deposit; 1-3 years to bring a mine into production.

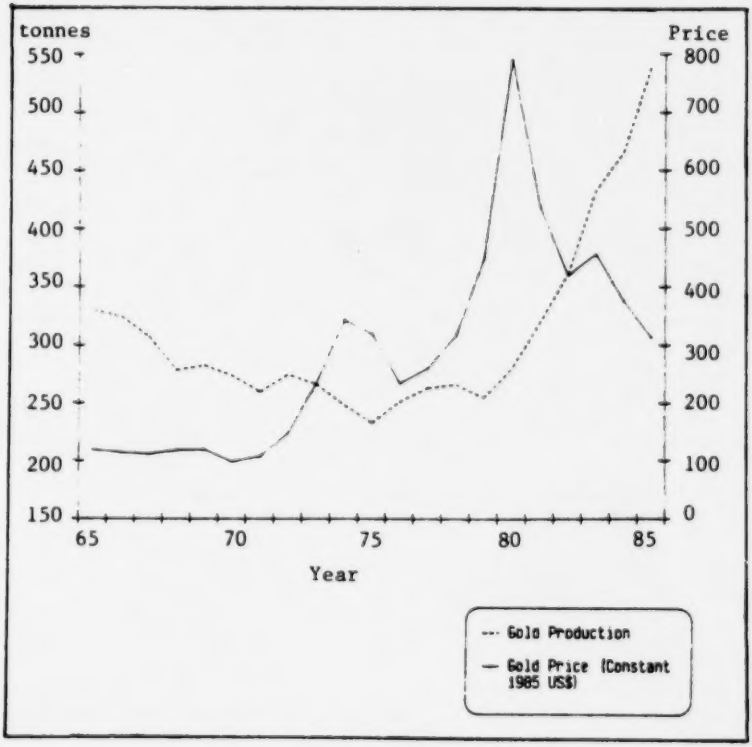


Figure 1. Effect of Gold Price on Mine Production in Western World Outside South Africa

Source: Brook Hunt & Associates Ltd., 1986.

Since 1980, the continued impetus from exploration and the perceived profitability of gold mining have pushed up mine supply from the Western World outside South Africa at the extraordinary rate of over 14 percent per annum for the five years to 1985.

Given the increasing rate of exploration expenditure, are we likely to see this rate of increase in non-South African supply continuing? And if so, for how long? It is perhaps pertinent to observe that, in 1980, no forecaster predicted anything like the current level of production.[1,2,3] The predictions made in 1978-81 were generally of less than 350 tonnes per annum for 1985. Even as recently as 1983, predictions for 1985 underestimated supply by 20-25 percent.

There is, moreover, no reason to believe that our ability to analyze the prospects for future production is any better now than it was in 1980. Clearly most forecasts of future production are, of necessity, based on currently known information. It is difficult to make meaningful estimates of production from deposits which may be found in the future, or to take account of developments which are not yet in the public domain.

South Africa

South Africa is a case apart. In the rest of the Western World, the high level of exploration expenditure had, and

1. H.W. Brook, in "The Future World Price of Gold" in 1981 predicted supply from all other non-Communist nations than South Africa in 1987 at:
   Gold price $375 per oz in 1981 money,
   235-255 tonnes
   Gold price $750 per oz in 1981 money,
   280-335 tonnes
2. C. Glynn, Consolidated Gold Fields, predicted in 1978: "Western World mine gold supply is likely to stabilize at about 1,000 tonnes per annum over the next decade" (South African supply predicted at 650-700 tonnes, hence by difference implying 300-350 tonnes from all other non-Communist nations other than South Africa).
3. We have sighted private company forecasts between 1980 and 1983 which predicted gold supply from the Western World outside South Africa at 300-450 tonnes in 1985. (The 450 tonne prediction was the result of a very careful and detailed analysis in the second half of 1983, but still fell short of the actual by some 20 percent.)

still has, a reasonable expectation of finding new deposits comparable with current operations. In South Africa, however, 98 percent of gold production emanates from the Witwatersrand gold mining basin, an area that has for many years been the focus of intense exploration activity. Despite this activity, no major extensions to known mining areas, comparable to the Klerksdorp area or the Free State goldfields, have been discovered since the early 1950s. If new deposits are to be found in future, they are likely to be deep, possibly badly faulted and relatively low grade, at or below the current production yield of 6.4 g/t. The capital and operating costs associated with their development would make such ventures highly speculative. Such new mines as are currently under consideration in South Africa are generally very low grade and/or deeper extensions of established operations. Many would probably not be viable but for the ability to write off capital expenditure against the tax payable by existing highly profitable operations (in effect the existing high grade mines are subsidizing deep, low grade projects).

The maturing nature of the South African gold mines is illustrated by the rapid grade decline over the past fifteen years. The average grade of the primary producers has fallen from a peak of 13.3 g/t in 1970 to under half that figure in 1985. Only a part of this decline can be attributed to the reduced pay limits resulting from higher gold prices.

Although we believe the possibility of finding significant new deposits in South Africa may be discounted in view of the intensity of past exploration, the metal price will affect production from existing mines. In this context, it is not the dollar price that is important but the rand gold price and its relationship to costs in South Africa. Mainly political considerations have led to a fall in the value of the rand over the past five years that is only partly compensated by increases in the cost of living. As a result, the rand gold price is now almost double that in the peak dollar price year of 1980, and despite double digit inflation, rand costs have risen less than the rand price. A true perspective on this may be obtained by pointing out that the relationship of operating cost to gold price in South Africa is much more favourable now than it was in 1980, when the gold price averaged over $600 per ounce. The difference between now and 1980 is that no one believed the 1980 situation could last, whereas the present relationship between cost and price is viewed as representing the future norm on which planning may be based.

Table 4

SOUTH AFRICAN ORE GRADES AND GOLD PRODUCTION, 1970-85

	Grade (g/t)	Production (tonnes)
1970	13.28	988.9
1975	9.63	713.4
1970	7.28	675.1
1981	6.92	657.6
1982	6.76	664.3
1983	6.56	679.7
1984	6.44	683.3
1985	6.10	673.3

The increased gold price in rand terms over the past three years will certainly have led to an expansion of payable reserves, with its concomitant decrease in pay limits and likely increase in mine life. In the short term, however, lower pay limits are likely to lead to reduced gold output. These interrelated factors need to be combined with the detailed assessment of mine operations and political change to arrive at an evaluation of future South African production. At Brook Hunt we annually review all estimates of future production, costs, grade trends, pay limits, etc., for Western World gold producers. The current revision is concentrating on a total reassessment of future South African gold production.

The Cost and Profitability of Gold Mining

The profitability of gold mining over the past five years has been a major factor in persuading mining companies to increase their exposure to the metal. For each year since 1979, over 90 percent of gold production in the Western World has shown an operating profit. No other metal has come anywhere near this record in recent years. Tables 6, 7 and 8 show the relationship between operating cost and metal price from 1975-85 for the Western World as a whole, and for South Africa and the rest of the Western World separately. From the data shown, it may be deduced that the gold price would have to fall below $250 per troy oz (in 1985 dollars) before it had any significant effect on primary gold production.

Table 5

SOUTH AFRICAN GOLD PRICES: EXCHANGE RATES AND INFLATION

	Gold Price	Exchange Rate	Rand Gold Price		South African CPI[a]
	(US$ /oz)	($/Rand)	(Rand/ oz)	(1975= 100	(1975=100)
1975	161	1.366	118	100	100.0
1976	125	1.150	109	92	111.2
1977	148	1.150	128	108	122.3
1978	193	1.150	168	142	134.8
1979	307	1.188	258	219	152.0
1980	612	1.285	476	403	172.9
1981	460	1.149	400	339	199.1
1982	377	0.925	408	347	228.4
1983	424	0.899	471	399	256.7
1984	360	0.695	518	440	286.5
1985	313	0.456	699	592	332.9
1986[e]	350	0.410	854[b]	724	398.4

[a] Consumer Price Index.
[b] Current gold price (mid-September 1986) R950/oz.
[e] estimated

Table 6[a]

WESTERN WORLD GOLD COST DISTRIBUTION
(all sources: primary and co/by-product gold)

	Gold Production Cost[b]					Gold Price[b]		
	Lower Quartile	Median Cost	Weighted Average	Upper Quartile	Ninth Decile	Annual Average	Monthly Average High	Low
1975	62	79	89	108	147	161	180	139
1980	180	214	237	272	429	612	675	514
1981	197	250	275	323	445	460	557	409
1982	184	243	256	311	365	377	444	315
1983	220	271	278	344	401	424	491	382
1984	173	254	255	311	350	360	394	319
1985[e]	158	239	232	273	318	319	330	300

[a] Source for tables 6-9 is Brook Hunt Annual Gold Cost Study (1985 edition).
[b] All costs and prices are in $/oz.

Table 7

WESTERN WORLD (EXCLUDING SOUTH AFRICA) GOLD COST DISTRIBUTION
(all sources: primary and co/by-product gold)

	Gold Production Cost					Gold Price		
	Lower Quartile	Median Cost	Weighted Average	Upper Quartile	Ninth Decile	Annual Average	Monthly Average High	Low
1975	105	121	123	145	159	161	180	139
1980	200	292	290	425	453	612	675	514
1981	244	343	317	399	500	460	557	409
1982	240	303	291	372	413	377	444	315
1983	232	299	292	353	415	424	491	382
1984	231	286	289	348	406	360	394	319
1985e	216	266	259	314	342	319	330	300

Table 8

SOUTH AFRICA GOLD COST DISTRIBUTION
(all sources: primary and co/by-product gold)

	Gold Production Cost					Gold Price		
	Lower Quartile	Median Cost	Weighted Average	Upper Quartile	Ninth Decile	Annual Average	Monthly Average High	Low
1975	61	76	83	100	133	161	180	139
1980	180	211	226	265	380	612	675	514
1981	186	236	265	318	417	460	557	409
1982	170	237	245	295	346	377	444	315
1983	181	268	273	321	401	424	491	382
1984	166	238	242	307	342	360	394	319
1985e	154	236	220	269	305	319	330	300

Present and Future Gold Supply

In this section we present expectations consistent with a gold price in the range $350-400/oz in 1986 money terms.

Table 9

PERCENTAGE OF PRIMARY PRODUCTION SHOWING AN OPERATING PROFIT (on net cash costs)

	Gold	Copper	Zinc	Aluminum
1979	97	92	95	NA
1980	100	95	94	94
1981	92	54	74	73
1982	91	42	60	11
1983	94	65	74	86
1984	93	60	87	81
1985	91e	84	82e	62

NA = not available

At such prices we believe the current high exploration momentum will be maintained, as the gold industry continues to show significantly better profitability than any other metal.

South Africa

Past gold production levels in South Africa are known with comparative certainty, as there is little or no illegal or unrecorded gold mining. The figure of 673 tonnes for 1985 may be accepted with some confidence.

Consolidated Gold Fields' analysis Gold 1986, contains an evaluation by the Chamber of Mines of South Africa which indicates the dependence of future production on metal price. Clearly, the evaluation was written no later than early 1986 as it takes no account of the latest political unrest or the further devaluation of the South African rand. The forecasts were made on the basis of gold prices between 530 and 650 rand/oz, compared with the present price of almost 1,000 rand/oz. Although some of the recent rand devaluation will soon be discounted by increased inflation, it seems likely that the current political situation will result in a much higher effective gold price than has hitherto been used for planning purposes in South Africa.

Beyond the year 2000, the Chamber of Mines foresees a rapid decline in South African gold production to between 280 and 500 tonnes per annum in the year 2020.

Most other observers, including ourselves, believe the Chamber of Mines is somewhat optimistic and that the

Table 10

SOUTH AFRICAN CHAMBER OF MINES GOLD PRODUCTION FORECASTS
(tonnes per annum)

	Gold Price in 1985 Terms (Rand/oz)		
	R530	R590	R650
1986	700	687	675
1988	712	707	697
1990	722	724	713
1995	709	724	774
2000	695	724	845

decline in South African production may well come sooner than they have forecast, perhaps as early as the mid-1990s. There seems little doubt, however, that exceptionally high gold prices in rand terms will delay that decline and will result in significantly higher gold production than would otherwise have been the case in the decade from 1990 to 2000. In the short term, i.e. the next five years, higher prices will have opposite effect (i.e. will reduce production) as the mines operate to generally lower cutoff grades.

The foregoing comments take no account of the political and economic changes which are taking place in the country. Production from the gold mines could be affected on three counts:

i political unrest spilling over into major stoppages or curtailment of operations, with possible racial conflict in the mines, power disruptions, strikes, etc.;

ii rapid escalation of costs, due first to the mines meeting some of the more excessive claims from the unions in order to keep production going, and secondly to the increased cost of spares and imports that would result from sanctions;

iii loss of skilled technical labour as non-South African staff emigrate. It should be recognized that the South African universities on their own are totally unable to meet the mines' requirements for mining, mechanical, electrical and metallurgical engineers. They have long

relied on the output of graduates from other countries, which is now drying up.

In the long term, we believe the last named factor will be the one the mining companies find most intractable. The history of mining operations in countries beset by unrest suggests that the unrest alone will have little effect (except in the minds of observers who may push the price up in expectation of disturbance to supply). Increasing costs will no doubt be largely contained by further weakening of the rand. The loss of technical expertise, however, is certain to affect the mines' ability to operate under extremes of depth, temperature and rock pressures. As a result, the expansion of ore production which is necessary to maintain gold output in the face of decreasing grades may be almost impossible to implement. Our final estimate of gold supply from South Africa in the year 2000 is much higher than we had been forecasting only 18 months ago. This does not indicate a radical change of view, but rather the realization that the unexpectedly high metal price in rand terms is likely to postpone the inevitable decline in South African production by about 5 years.

Best estimates of future South African gold supply:

1990 - 690 tonnes
2000 - 590 tonnes

Rest of the Western World

The forecasts throughout this section make some allowances for additional development, particularly in the 1990s, of mines and resources which have yet to be discovered, or details of which are not yet within the public domain.

Canada

Production in 1985 was some 86 tonnes. In the near future, this can be expected to increase to over 100 tpy as the Hemlo goldfield reaches full production. The rate of discovery of new resources, however, has slowed during the past two to three years, and there is reason to doubt whether the recent rates of growth can be maintained. Canada has been an important gold exploration target for a number of years. Outside South Africa it has probably been the number one target country for much of the last decade and much of what is there has probably been found already. For this reason, we expect that Canada's gold

production will decline during the 1990s. Some operations such as Cominco's Con and Detour Lake are likely to close permanently and there are reserve limitations for a number of others.

Best estimates of Canadian gold supply:

1990 - 110 tonnes
2000 - 95 tonnes

United States

In 1985 gold production was some 79 tonnes in the United States. Like Canada, the USA has been the subject of intensive exploration activity in recent years. As a result, gold output has increased steadily from a level of about 30 tpy prior to 1980. Further increases in the short term may be expected from the reopening of Bingham Canyon, from Goldfields Mesquite, Centennial's Montana Tunnels, and Sonora's Jamestown, among others. It may, however, prove difficult to maintain the momentum during the 1990s as a number of the recently opened projects have a relatively limited life (10-18 years only). As in Canada, U.S. gold production may trend downwards from 1990, but it is pertinent to note that just within the last six months developments at Bingham Canyon and the announcement of a major increase at Round Mountain go against this trend.

Best estimates of U.S. gold supply:

1990 - 100 tonnes
2000 - 85 tonnes

Brazil

Production was estimated at 65 tonnes in 1985. Brazilian gold production has not been easy to evaluate for some years, as a significant amount is produced by garimpeiros who frequently choose to dispose of their output in neighbouring countries to take advantage of a larger central bank premium. Garimpeiro production has increased rapidly in recent years, and may be expected to continue to do so with the present regime's encouragement. There seems, moreover, little doubt that in many places garimpeiro operations will be succeeded by more oganized mining and by treatment of the relatively rich dumps left by the present rather crude extraction methods. With the prospective and largely unevaluated nature of much of Brazil, continuing expansion may be expected for some years, as long as the

country's regime is favourable. Prospects for an increased level of hard rock mining must also be good, although little further development is expected before 1990 once the Gencor Sao Bento and RTZ Morro de Ouro operations are commissioned.

Best estimates of Brazilian gold supply:

1990 - 85 tonnes
2000 - 140 tonnes

Australia

Gold production in 1985 was 57 tonnes, an increase of 18 tonnes over the 1984 figure. The gold mining boom in Australia continues apace. A recent analysis by the stock-brokers JB Were predicts a production of well over 100 tonnes by the year 1990, and, although most would consider this optimistic, it is fair to point out that, in 1980, no one foresaw a production of over 50 tpy by 1985. Gold prospecting activity has been high for some years, however, as it has in both Canada and the United States. Much of the increased production in Australia has come, not from new mines, but from deposits and mining areas which had been abandoned many years ago. We doubt, therefore, that the present momentum can be maintained. A further factor in Australia is the limited reserve of many of the new operations. We expect, therefore, that Australian gold production will trend downwards in the 1990s.

Best estimates of Australian gold supply:

1990 - 100 tonnes
2000 - 80 tonnes

Philippines

Production in 1985 has been quoted at 38 tonnes, of which some 25 tonnes was recorded production from primary hard rock mines and co/by-product gold from other mining. The small mining sector is particularly difficult to quantify: 12-13 tonnes are believed to have been produced and sold within the country, but a further 15-30 tonnes may well have emanated from within the Philippines and been sold outside that country. There is little doubt that the small mining sector has been much more active than would be suggested by gold sales within the country. Overall production from the Philippines in 1985 may have been as high as 50-60 tonnes.

Clearly there is much prospective ground in the Philippines, but exploration activity has been at a low level for many years due to the insecure political regime. If Mrs. Aquino should succeed in bringing stability to the country, together with more favourable conditions for foreign investment, the gold mining sector might well experience a major expansion in the 1990s.

On balance, however, we are not optimistic for any early improvement in conditions; moreover, the present high level of small mine activity may well subside if it does not receive better government support.

Best estimates of Philippine gold supply:

1990 - 45 tonnes
2000 - 50 tonnes

Papua New Guinea

Gold production in 1985 was 33 tonnes. Gold output in 1985 rose more sharply than most observers had expected as Ok Tedi overtook Bougainville as the country's principal producer. While the current production rates from Ok Tedi will not last long, overall production from the country seems certain to increase over the next fifteen years. There is intense exploration activity and numerous important finds have been made, of which Porgera, Lihir Island and Misima Island are outstanding examples. By the mid-1990s, these three alone could be producing at a combined rate of 25-30 tpy. There are at least a further eight known prospects which could develop into operating mines by the turn of the century. This number could again be increased if and when the exploration moratorium is lifted on Bougainville and Buka Islands.

Best estimates of Papua New Guinea gold supply:

1990 - 30 tonnes
2000 - 55 tonnes

Latin America (excluding Brazil)

Gold production, estimated at 99 tonnes for 1985, has increased in Latin America (excluding Brazil) by some 85 percent over the past 5 years, with major increases being posted in Chile, Peru, Columbia and Venezuela. A fair proportion of this gold bypasses official channels and the true total for 1985 could have been anywhere between 90 and 110 tonnes.

Prospecting and exploration activity is certainly at a high level in most of the Andean cordillera, except the southern parts of Chile and Argentina (which are nonetheless highly prospective; the difficult climate and terrain have been a major deterrent). We see no reason why the recent rate of increase should not continue for some time if the gold price remains right. Ecuador in particular is moving towards a more encouraging regime for mining and could again become the major producer that it was in the Spanish colonial era.

Best estimates of Central and South American gold supply (excluding Brazil):

1990 - 120 tonnes
2000 - 150 tonnes

Africa (excluding South Africa)

Production in 1985 is estimated at 50 tonnes.

While output from the main producers in Zimbabwe, Zaire and Ghana is recorded accurately, much of the output from the rest of Africa bypasses government agencies. Nonetheless, there is reasonable agreement between Consolidated Gold Fields, BRGM and others that the total output is currently in the region of 50 tonnes per annum. There is, moreover, the prospect of significant increases over the next 15 years as governments seem to be gradually changing their attitudes to private enterprise in gold mining. The West African states in particular may be expected to expand production. There are numerous prospective areas in Ghana, Guinea, Mali and the Ivory Coast. In Ghana alone, production is expected to expand from the current level of around 12 tpy to over 18 tpy in the early 1990s. If the metal price remains at current levels, prospecting activity will almost certainly increase, leading to the commissioning of further new projects by the turn of the century.

Best estimates of African gold supply (excluding South Africa):

1990 - 65 tonnes
2000 - 90 tonnes

Rest of Western World (in aggregate): Europe, Middle East, Other Asia, Other Oceania

Although the remaining countries of the Western World only contributed an estimated 31 tonnes between them in 1985,

there are prospects for some fairly large increases in the next 15 years. Indonesia is probably the most interesting country, with a very high level of exploration activity and numerous interesting showings, particularly Kalimantan. Output from Indonesia could increase from the present figure of about 5 tpy to anything from 8-30 tpy by the year 2000. Saudi Arabia has two major projects which will add a further 6 tpy. Japan's Hishikari has yet to reach its full capacity of 6-7 tpy. Western Europe could also bring in a further 3 tpy capacity before 1990. New Zealand has numerous interesting prospects, and would also be well placed to increase production given a more favourable political climate for gold mining. In aggregate, this miscellaneous grouping of countries is likely to give rise to a number of major producers by the year 2000.

Best estimates of gold supply from these remaining countries:

1990 - 40 tonnes
2000 - 75 tonnes

Western World Gold Production: Aggregated but Excluding South Africa

The individual estimates add up as follows:

Table 11

HISTORIC AND FORECAST GOLD PRODUCTION
Western World (excluding South Africa)

	1980	1985	1990	2000
North America				
United States	30	79	100	85
Canada	51	86	110	95
Latin America				
Brazil	35	65	85	140
Others	54	99	120	150
Africa				
(excl. South Africa)	33	50	65	90
Australia	17	57	100	80
Papua New Guinea	14	33	30	55
Philippines	22	50	45	50
Other Western World	23	31	40	75
Total	279	550	695	820

It should be noted that we have made no allowance in these estimates for the possible discovery of a gold province in any way comparable with the Witwatersrand basin in South Africa. We believe that the existence of a similar deposit elsewhere in the world is conceivable - West Africa, Brazil and India are possible locations. The likelihood of such a discovery is small, however, and the logistics of its development would preclude it having any great effect on gold supply before the year 2000.

The Eastern Bloc

Although perceived price and profitability may not be the stimuli for the Eastern Bloc that they are in the West, we nevertheless believe there will be strong pressure for increasing Eastern Bloc gold production, and supplies to the Western World, over the next fifteen years.

For many years the USSR has relied on oil and oil products for a large part of its export hard currency earnings from the non-communist West. These earnings have been severely reduced since 1984, not only by the fall in oil prices but also by reduced production as reserves of easily accessible oil are declining. We believe that the USSR will seek urgently to replace the falling revenue from oil by other exports in order to maintain some sort of balance of trade. Since the West has little interest in Soviet manufactures, there will be increasing pressure to export primary mineral wealth other than oil. Some evidence of this may already be seen in the nickel industry, where Western (Finnish) technical assistance has been engaged to improve operation of the new nickel refinery at Monchegorsk.

The result of this increasing pressure for export earnings on gold production is difficult to anticipate, particularly in view of the uncertainty that exists about current production levels. Western World estimates of USSR production in 1984 range from 270 to 360 tonnes. Predictions we have sighted for the year 1990 range from the low of 310 tonnes predicted by the U.S. Bureau of Mines, based on their estimate of output from known mines, to a high of almost 500 tonnes, based on the belief that economic pressures will force the government into some massive promotion of gold mining. This latter figure probably underestimates the difficulty of expanding production due to the extreme climatic conditions in the more prospective areas in Siberia, but we nonetheless believe that an increase by 1990 to 350-400 tpy is well within the bounds of possibility, rising perhaps to 400-475 tpy by the year 2000.

The People's Republic of China is the only other significant Communist Bloc gold producer. Chinese gold output has been rising rapidly in recent years, from an estimate of around 45 tonnes in 1980 to perhaps 70 tonnes in 1985. The present government plans for a doubling of the 1980 production by 1990, and for a quadrupling by 2000. From what we know of the current operations and prospects, this latter target, though ambitious, should not be regarded as impossible.

The increasing production of gold by the Communist Bloc, combined with its requirements for foreign exchange, will almost certainly result in greater availability of their gold to Western World markets. In addition to current production, the Eastern Bloc's above-ground stocks of the metal probably amount to some 2,500 tonnes. Whether they will be persuaded by economic factors to reduce this stock must be in doubt, but we feel that an expansion from the current level of net East/West trade of some 200 tpy[5] to 350-400 tpy by 1990, is by no means unlikely.

A Scenario for Mine Gold Production to the Year 2000

Based on the foregoing, an assessment of mine gold production to the year 2000 is presented in the following table.

Table 12

MINE GOLD PRODUCTION, HISTORIC AND FORECAST
(tonnes gold)

	1980	1985	1990	2000
South Africa	675	673	690	590
Rest of Western World	279	550	695	820
Western World Total	954	1,223	1,385	1,410
Eastern Bloc	335	390	465	590
Grand Total	1,289	1,613	1,850	2,000

5. Source: Consolidated Gold Fields, Gold 1986.

It is reemphasized that the above summary and all the foregoing figures incorporate an allowance for production from as yet undiscovered or unpublished gold deposits and in consequence leads to an overall gold production forecast appreciably higher than an assessment of future output based entirely on existing mines and known projects.

While presenting the above figures as a best estimate, we feel that an understanding of the forces at work is of greater importance than any formal forecast.

For the Western World outside South Africa, the continuing exploration momentum led by 1985 to an increase in production of 271 tonnes, or 97 percent, compared with 1980, a rate of increase that was certainly not foreseen at that time. It may well be questioned whether the present postulation of further rises of only 145 tonnes by 1990 and 270 tonnes by the year 2000, which represent far slower rates of growth than in the past five years, is not too conservative. It may be; we believe, however, that in the three principal countries - the United States, Canada and Australia - the high exploration effort has probably reached the point of diminishing returns, and that future growth will prove more difficult. Elsewhere, higher rates of growth may well run into political/social/economic limitations, as in the Philippines, Africa and much of Latin America. Any real improvement in the economic climate for gold mining by private enterprise in these areas could result in our longer-term forecasts being surpassed by a possible wide margin.

The influence of the metal price will be paramount. All our estimates are conditional on a gold price in the range $350-400 per ounce in 1986 money terms. While higher prices are unlikely to have much effect, a fall in the gold price to below $300 for one or more years would radically change the outlook towards investment and exploration that is currently so favourable.

In South Africa, the stimulus given to gold mining by the unprecedented rand price for the metal will certainly prolong the life of the industry. In addition, while the country is beset by political uncertainty, the metal price will probably remain high. That uncertainty, however, is likely to limit the industry's ability to expand production. Should the South African political situation be resolved soon, which we believe most unlikely, the effect on gold prices and/or supply could be considerable. Beyond the year 2000, the ore reserve limitations must lead to a continuing decline in the country's gold production under any political or metal price scenario. Even by 1990, aggregate production from other Western World producers is

likely to exceed that of South Africa for the first time since 1953.

Contrasting with the decreasing importance of South African supply in the gold market, the economic forces on the Eastern Bloc seem certain to promote a steady increase in production, to the extent that, at some point early in the next century, the USSR will succeed South Africa as the World's largest gold producer.

EXCHANGE RATES - FACTORS WHICH AFFECT THEM AND THEIR IMPACT ON GOLD

Martin Murenbeeld

Introduction

Exchange rates are important to gold. For one thing, we cannot talk about gold without expressing its value in one currency or another. By convention this currency is the U.S. dollar. A miner in Canada, however, views gold in terms of Canadian dollars, a buyer in Japan sees gold in terms of its Yen value, while a Swiss banker invests in gold with a view to its Swiss franc value. The price of gold, in fact, is a question of one's currency perspective, usually determined by one's place of residence. Some of the most basic decisions about gold - whether to mine it, how to sell it - are dependent upon the gold price; the gold price, in turn, is in part a function of the currency in which those decisions are made.

To understand the forces at work on the gold price, one must have some understanding of currency values. Indeed, how can it be that the average price of gold rose from $458 in 1980, to $716 in 1985, when gold actually declined from a peak of over $800 to just below $300 in that period. Figure 1, which plots gold on both a U.S. dollar and a rand basis, indicates that this is what happened when the gold is valued on a South African rand basis.

Three currencies, all of which are important to gold, will be discussed in this paper - the U.S. dollar, the Canadian dollar and the South African rand. I will conclude with some comments on the currency factor in gold demand/supply considerations.

The U.S. Dollar

The U.S. dollar is the most important currency in the world, well, almost. I have always been intrigued by the fact that, when Gary Powers' U-2 plane was shot down over Russia in 1959, it was revealed that his spy kit contained, along with the obligatory death pill (which he didn't swallow, to great U.S. embarrassment) some gold coins! When you're shot down over Russia, what are you going to pay with U.S. dollars?

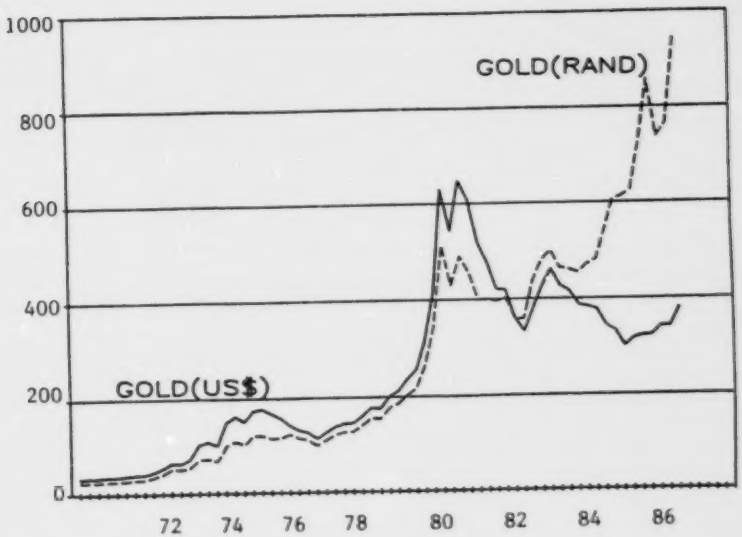


Figure 1. Gold (U.S.$) vs. Gold (Rand)

For those of us who do not normally get shot down over Russia, the U.S. dollar is the most internationally acceptable medium of exchange. It is also the world's numéraire, and for better or worse, its general store of value. Indeed, the dollar satisfies all the theoretical criteria of an international monetary item.

For our purpose, the U.S. dollar is also the numéraire for gold. We value gold in terms of the dollar, and contracts relating to gold are written in terms of U.S. dollars. The dollar, however, is not a passive numéraire; its value in terms of other things also goes up and down. This volatility affects gold's value in terms of U.S. dollars. In other words, the true value of gold is not specifically dependent upon its numéraire. If the U.S. Federal Reserve floods the world with U.S. dollars and the true value of gold has not changed, gold will have to go up in terms of U.S. dollars.

We recognized very early in our research that the U.S. dollar itself has an impact on the price of gold. This fact has become more widely accepted in recent years. Commentators today can be heard to say that gold declined because the dollar rose, or that it rose because the dollar declined. Figures 2 and 3 show this phenomenon in a new

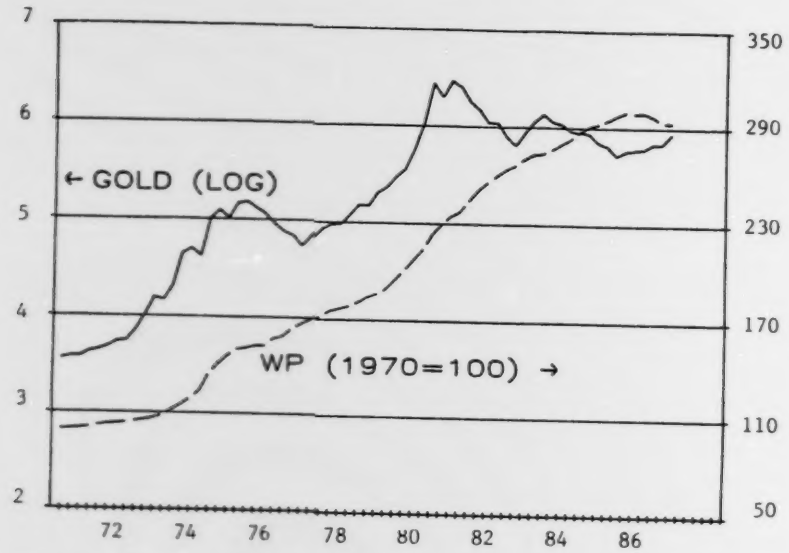


Figure 2. Gold vs. WP (Weighted Sum - 7 Countries)

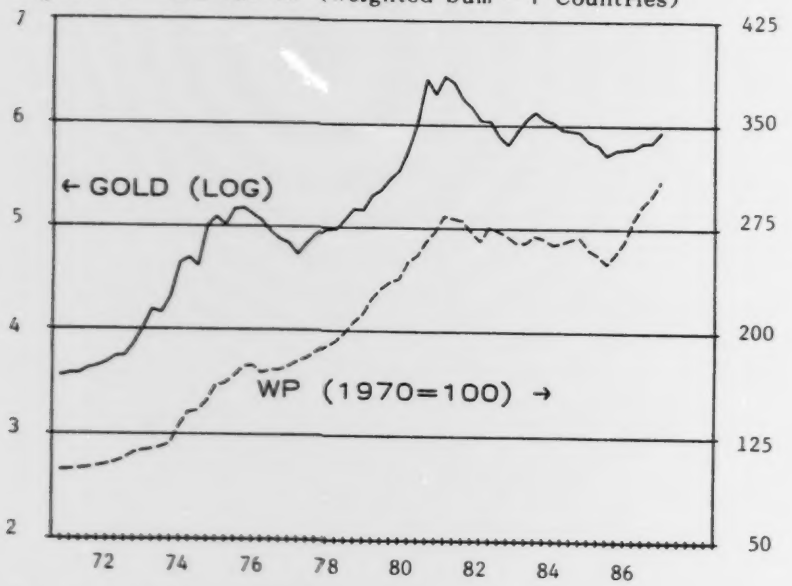


Figure 3. Gold vs. WP (Currency Adjusted)

and interesting way. Figure 2 plots the log price of gold versus an index of world inflation. The index of inflation rises without fail every year, except in 1987, while gold exhibits a much stronger cyclical pattern. There does not appear to be a strong relationship between the two.

Figure 3 plots the log of gold versus the same index, but this time it is U.S. dollar adjusted. The index, in other words, is now not simply the weighted sum of a number of individual inflation indices, but the weighted sum of individual inflation indices all converted to U.S. dollar inflation indices. I have never failed to be impressed by this chart. It not only shows how strong the relationship between inflation and gold really is, but it also shows how important a role the U.S. dollar plays in the nominal valuation of gold. From several perspectives - from the dollar's role as a numéraire, and from the dollar's role in inflation analysis - a clear relationship is visible. Gold rises as the U.S. dollar declines, and gold declines as the U.S. dollar appreciates, all else being constant.

What factors affect the U.S. dollar? When I first started work on a Ph.D. thesis in 1972 I posed a similar question. Business and economic journals were full of lists of factors that affect currency values. Indeed, an inclusive list of factors that we know at one time or another to have caused currencies to appreciate or depreciate could be quickly generated. Factors that come to mind quickly include relative levels of interest rates, inflation, and monetary growth rates. And one cannot forget budget deficits. Were I to describe the most significant development underlying the U.S. dollar's rise and subsequent fall in recent years, it would include the shift from a restrictive monetary policy juxtaposed on an expansionary fiscal policy (with the resultant rise in the level of real U.S. interest rates), to a more expansionary monetary policy juxtaposed on a somewhat less expansionary fiscal policy (which put some downward pressure on the real interest rate level in the U.S.). The first policy mix induced a massive inflow of capital to the U.S. (This happened in an environment of few alternative non-U.S. investment opportunities, and a U.S. tax environment which greatly increased the real return on capital.) As a result the U.S. dollar was bid up. The mirror image of the capital account surplus was the current account deficit.

The second policy setting was in no small degree the result of the hardships the strong dollar was generating domestically, and internationally. Voters in depressed manufacturing sectors of the U.S. economy spawned protectionist Congressional forces. Congressmen in turn became

unwitting cohorts of LDC (Less Developed Country) governments dependent upon commodity prices. Each group ended up wanting a lower dollar. The G-5 agreement to devalue the dollar was validated, however, by a significant shift in federal policy, and the attempt to reduce the U.S. budget deficit.

This brief synopsis of the U.S. dollar's recent development does not minimize other factors which have played a role in the U.S. dollar's ups and downs in recent years. The trade balance, capital flows, relative economic growth rates, and politics all can be identified as critical. Indeed, my experience has been that analysts are like the blindfolded men each describing an elephant by touching it. While none may agree, if in the end they all identify the beast as an elephant they are on the right track.

Purchasing Power Parity

The question that comes to mind at this point is whether there are some long-term factors which drive exchange rates - factors over and above monetary and fiscal policy which I feel to be absolutely critical, but which are of a relatively short-term nature.

The most durable theory of exchange rates is Purchasing Power Parity, or PPP. In practical terms, this theory indicates that currency values reflect the inflationary erosion of their purchasing power. Currencies exhibiting a high relative rate of inflation exhibit, it is held, a high rate of depreciation. I don't think anyone would question this basic postulate. We have all seen countries exhibiting exorbitant rates of inflation relative to the U.S., experience periodic currency crises and massive devaluations. The theory has gut-feel validity.

There are some problems with the theory when one goes beyond this basic interpretation. Many observers attribute more to PPP than it can reasonably deliver. They feel the theory implies there is some level indicated by PPP above which a currency is overvalued and below which a currency is undervalued. I have long ceased to be an academic expert on the nuances of PPP theory and cannot argue this point other than by pointing out the following practical violations of the theory:

- price indices include prices of goods not internationally traded;
- there are frequent changes in consumer tastes, technology and product quality;

- capital assets fall outside the basic theory;
- there are impediments to the free international flow of goods, services and capital;
- and not least important, one never knows when currencies were at purchasing power so as to start the analysis.

Table 1 presents the results of my firm's multilateral purchasing power parity model.

Column 1 presents exchange rates for 31 July 1986. Column 2 has converted these exchange rates to effective rates. The 4.39 for the U.S. dollar means that the U.S. dollar has appreciated by 4.39 percent since January 1970 on a trade-weighted average basis against the other nine currencies, and the -21.77 percent means that the Canadian dollar has declined by 21.77 percent on a trade-weighted averaged basis since then.

Columns 3 and 4 present wholesale and consumer price inflation on an effective basis since January 1970. The 17.56 for the U.S. effective wholesale price inflation means that the other nine countries have inflated more rapidly than the U.S. on a wholesale price basis - by a total of 17.56 percent on a trade-weighted average basis to date. From a wholesale purchasing power parity point-of-view, the U.S. dollar's effective value should be 17.56, and not 4.39.

Table 1

RESULTS OF M. MURENBEELD & ASSOCIATES LTD. PPP MODEL

	Actual Exchange Rates	Effective Exchange Rates	Effective Wholesale Prices	Effective Consumer Prices	Wholesale Price Equilibrium	Consumer Price Equilibrium
US	100.0	4.39	17.56	18.98	100.0	100.0
CN	72.52	-21.77	-14.36	-6.29	75.12	81.44
JP	153.8	142.37	46.19	11.02	267.2	349.4
UK	149.2	-41.23	-47.59	-40.90	120.1	128.9
GE	2.093	99.79	70.93	91.25	2.746	2.612
FR	6.803	-16.93	-6.22	-15.35	7.044	7.991
NE	2.359	46.22	32.52	25.33	2.951	3.248
BL	43.65	7.33	37.53	10.74	39.72	51.18
SW	1.678	177.12	111.94	77.94	2.561	3.099
IT	1437.	-61.55	-63.27	-60.95	1706.	1681.

Columns 5 and 6 present a set of exchange rates that are at wholesale price purchasing power parity (WP-PPP) and consumer price purchasing power parity (CP-PPP) respectively. Note that there is little agreement between the exchange rates in columns 5 and 6 and the actual exchange rates in column 1. The Japanese and European currencies are far above their purchasing power value. The yen should be at 359.4 according to CP-PPP for example. The Canadian dollar is marginally below its WP-PPP rate of 75.12. Given that the average WP-PPP error is 20 percent, one cannot, however, conclude with any statistical confidence that, for example, the Canadian dollar is too low at its current level. Indeed, regardless of the yen's CP-PPP value, I am personally loathe to view the yen as too high at its current level.

Therefore, while the level which the PPP theory suggests is appropriate for each currency is open to serious question, I do want to point out that the direction of change for each currency over the period 1970-86 is perfectly correct. The Canadian dollar, sterling, French franc, and lira have declined on an effective basis since 1970, exactly as wholesale and consumer price developments suggest should have happened.

The Canadian Dollar

The purchasing power table makes clear that inflation has been a significant factor in the Canadian dollar's prolonged decline. Figure 4 makes this relationship more visual. It plots the Canadian dollar against Canada's effective wholesale price index on a monthly basis since 1971. Inflation indicates the Canadian dollar should have declined, and the reality is that it did.

Inflation is not the only factor which has affected the Canadian dollar, of course, and it may not even have been the most important factor. A factor which is not easy to plot, but which has had a major impact on the dollar over the last decade, is the Canadian political factor. The political factor in Canada is not an unidimensional one, however. There are at least three dimensions: the federal-provincial dimension, the nationalism dimension, and the made-in-Canada policy dimension.

Federal-provincial issues sap much of Ottawa's political strength. These last 10 years have been particularly difficult. Canada has had to fight a significant Quebec separatist threat, and much political capital was spent on constitutional issues. Economic issues were not of high priority during the Trudeau years.

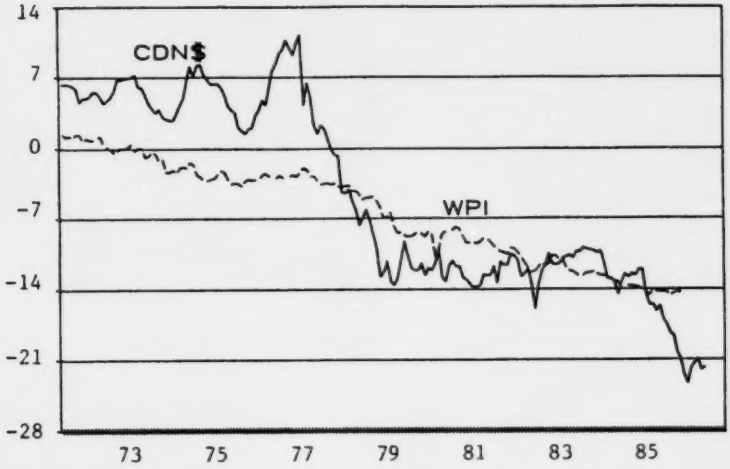


Figure 4. Effective Cdn Exchange Rate vs. Effective WP Index

One federal-provincial issue, which can best be categorized under the nationalist issue, is energy policy. The National Energy Policy was not only a major federal-provincial issue, but it also drove capital out of Canada because of its blatant nationalistic features. The policy damaged Canada's traditional image as a receptive host country for foreign investment - something from which the country has not fully recovered. That the policy, now dead, actually ended up damaging Canadian-owned energy companies and saving foreign-controlled energy companies from overindulging themselves in the days when oil prices were going to $100, is one of the significant ironies of this economic nationalism.

The third dimension of the political factor usually crops up in terms of a made-in-Canada interest rate policy. In the 1980s to date, U.S. interest rates have been extremely volatile. Because of Canada's heavy reliance on foreign capital, U.S. interest rates have a significant impact on the Canadian dollar. Any indication, therefore, that Canada will forge its own interest rate policy - which only means stopping domestic rates from rising (or forcing them lower) when trends in the U.S. dictate otherwise -

catches the Canadian dollar broadside. This factor has been the cause of several short-term Canadian dollar crises.

One numerical measure of the political factor is the Direct Investment account. Over the period 1974-79, total direct investment flows averaged an outflow of about $900 million per year. This outflow rose to an average of almost $5 billion per year in the period 1980-85. In contrast, for the period 1960-69, the net inflow averaged over $400 million per year, and not one year of that decade saw a deficit.

Beyond the inflation and political factors is a third variable critical to the Canadian dollar. It is one overlooked by many observers: Canada's non-merchandise trade balance, also known as the service account balance. The service account records such items as interest and dividend income (investment income), consultant fees, travel, etc. The service account balance for Canada is in significant deficit, $18 billion in 1985 for example. Of this $18 billion, $15 billion was due to the investment income deficit. This deficit is in turn related to the huge stock of foreign investment in Canada. In 1984 Canada's net international investment position was in deficit by $152.8 billion, and it is likely to be over $170 billion currently. Of this $152.8 billion, Canadian government debt obligations total over $70 billion (probably over $80 billion currently).

What would happen if all the money Canadians borrowed abroad in past years were poorly invested - invested, for example, in social infrastructure, electric generating capacity for which there is no demand, the search for oil in the Beaufort Sea, government transfer payments, in short, in activities which do not generate, directly or indirectly, foreign exchange? Clearly these investments would not themselves be able to service the U.S. dollar interest payments. Since, however, U.S. dollars must be purchased, all else being constant, the Canadian dollar will decline to the point where the trade balance surplus rises to equal this deficit on services. And the trade balance does not always offset for the service account deficit. Currently the quarterly current account deficit hovers near $2 billion, which means that the trade surplus is $2 billion less than the service account deficit.

Historically, Canada has run more current account deficits than surpluses. Capital inflows (the purchase of Canadian bonds, etc.) have generally caused the current account to be in deficit. But these capital inflows, of course, add to future service account outflows. Indeed, Canada has a serious structural problem which will keep the

dollar weak for many years to come. Only periodic waves of new foreign investment (as the result for example of high commodity prices, cheap labour, favourable tax treatment, etc.) can interrupt this prolonged period of weakness.

The South African Rand

The rand, and I only refer to the commercial rand in this discussion (the financial rand was reintroduced in September 1985 and trades at a 20-50 percent discount to the commercial rand), has declined very rapidly in recent years from a high of U.S. $1.50 in 1974. Political factors have played a role in this deterioration, and I will say more about this below. Inflation has probably had the most significant impact on the rand. The ratio of U.S. and South African wholesale price indices has deteriorated by over 60 percent since 1970. In fact South Africa has experienced double digit rates of inflation in 13 of the last 17 years. Inflation is currently near 20 percent. We know this rots a currency. While I am by no means an expert on the South African economy, and do not have as intimate a feel for developments there as I might have for Canada, it does not take intimate knowledge to suggest that a root cause of this inflation lies in the monetary sector. In 11 of the last 17 years, M1 growth (currency plus chequing deposits) in South Africa exceeded 10 percent, and in 26 of those 44 quarters the rate exceeded 20 percent. I am not sure that I understand the nature of the monetary control process in South Africa well enough to comment on this, but I am enough of a monetarist to worry about such excessive rates of growth.

There were two periods where the rand bucked the negative trend dictated by inflation: in 1972-74 and in 1980. Both these periods saw gold rise significantly on world markets. Indeed, gold is the second critical factor in the rand's profile.

Figure 5 shows how important this factor is in a statistical sense. It traces the rand against a regression model which includes inflation, money supply and the gold price. This model is estimated over the period from the first quarter of 1970 to the third quarter of 1986. The fit has an R2 of .95, which is surprisingly high given the model's simplicitly.

The problem with regression models, however, is that they try to explain events in terms of the variables in the model. If, as is the case with the rand, the currency

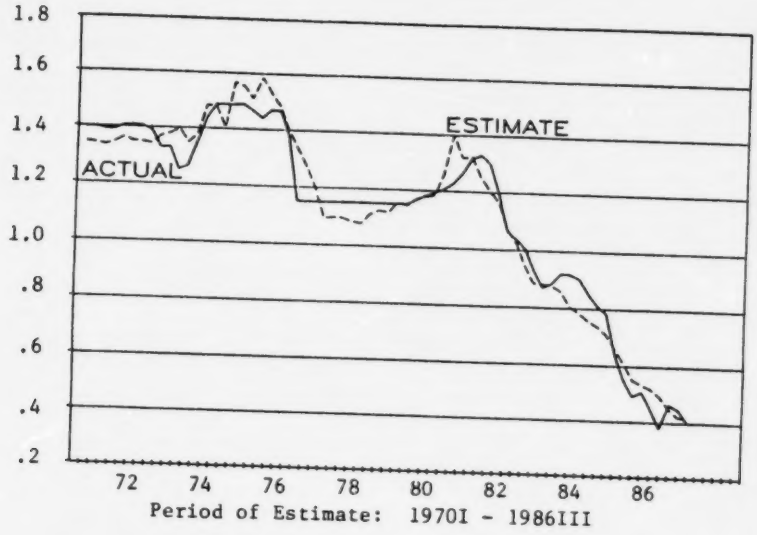


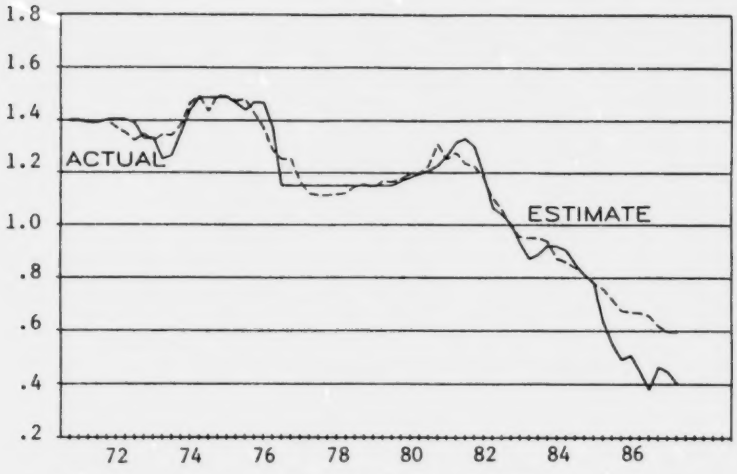
Figure 5. Rand vs. Model (WP, GO, M1)

drops because of a variable which is not included in the model, the model is pulled out of shape. In my opinion, the last several years of political strife in South Africa has had such an effect on the model.

Figure 6, which exhibits the same model, but calculated for the period 1970-1984, fits the data much better. This model is then used with the actual data from 1985 and 1986 to calculate what the rand would be, given inflation, monetary, and gold price developments over the last two years. The model indicates that the rand should trade around 60 U.S. cents and not the current 40-45 cent average. My conclusion is that the political deterioration in South Africa has cost the currency at least 15-20 cents in recent years. Given that it is difficult to see much improvement in the political factor, one might best count on the continuation of a 15-20 cent discount.

Currency Factors - Conclusion

I would therefore suggest that, while every currency has its own specific factors, there are two factors one can never overlook - inflation and politics. Indeed, some even



*Period of Estimation: 1970I - 1984IV
Model Estimate Thereafter

Figure 6. Rand vs. Model* (WP, GO, M1)

say the latter supersedes the former because it is the politician who sets the policies which generate inflation. I personally would have difficulty arguing with this view. The smartest investor I ever met told me he knew very little about currencies. He was heavily invested in Canada, but in the early 1970s he began to dislike Trudeau and he moved all his investments to Germany. He liked Schmidt and couldn't stand Nixon, Ford, and Carter. Around 1980 he closed out his investments in Germany, and quite accidentally sold his gold holdings the day gold peaked (he chuckled over that one). Reagan was about to be elected, he assured me, and he had therefore moved all his investments to the U.S. He wanted my opinion. I didn't give him one, rather I asked him what he was planning to do next. Unfortunately he passed away before 1985. But I have no doubt that had he lived, he would have taken a liking to Nakasone around February 1985 and myopic congressional protectionism would have caused him to invest in the Japanese stock market and in gold.

Politics - maybe this is the only factor.

Currencies and Gold Demand/Supply Considerations

Gold is like any other commodity - demand for it rises as its price declines, and demand falls as the price rises, all else being constant. Jewelry demand, for example, which accounts for over 50 percent of total gold demand, clearly falls off as the price of gold rises, and picks up as the price of gold falls.

The basic demand/price relationship, therefore, does exist in the gold market. In recent years, gold prices have dropped most in Japan - by 47 percent since the first quarter of 1983. The gold price has dropped only 30 percent in Germany and 16 percent in the U.S. A simplistic conclusion would suggest that demand for gold in Japan would have risen most in the recent three-year period. Indeed, one can at least conclude that the increased appetite for gold in Japan in recent years is in part the natural result of the yen's rise against the dollar (and gold's consequent plunge in yen terms). That Japan decided to issue an official coin in honour of the Emperor only added to an already stimulated appetite.

Supply is also affected by currency values; at least we think it is. As the price of gold rises, we believe miners will find it more attractive to explore for and mine gold. The data, however, does not show this clearly. According to Consolidated Gold Fields, total non-communist mine output was 1,274 tonnes in 1970. Gold prices have risen sharply since then. Mine output has declined, however, to a low of 954 tonnes in 1980 - the peak year for gold. Since then, it has risen to 1,213 tonnes, but it is still below the output of 1970.

The trend in Canadian mining output is not unlike the overall trend. Output declined in the early 1970s, stabilized in the mid 1970s, and exhibited a rapid rise in the 1980s. It would appear that the correlation is negative - supply declines when prices rise. While some miners suggest it is the mining of different grades at different gold prices which accounts for this, the critical factor is probably the time it takes for miners to respond to different price signals. Mine completion takes up to five years; gold properties discovered in response to a price runup will not be producing physical gold for four to five years. If we were to compare gold prices with mine output four years later, we would find a positive correlation between price and output.

It should also be clear that the Canadian dollar price of gold, currently near $600, has been a tremendously positive factor for Canadian gold mining. Gold has declined

not nearly as badly on a Canadian dollar basis as on a U.S. dollar basis. This brings us to a full circle. As I said at the start of this discussion, the price of gold is not the same for everyone.

GOLD PRICE FORECASTING: COMMODITY AND MONETARY PERSPECTIVES

Gerry Anders

Introduction

Over the past years, forecasts of the gold price have varied widely and most of these forecasts have erred - at least so far - substantially on the high side. They share in this respect the fate of the vast majority of forecasts for energy and for base metal prices.[1] Our record in the Metallic Mineral Section of the Ontario Ministry of Northern Development and Mines (formerly Ministry of Natural Resources) has over the past 13 years been rather better than the average, as far as base metals were concerned, and we have applied some of the lessons learned to gold price forecasting.

In a paper presented in June 1984 to the Eighth International Precious Metals Conference (the gold price at that time was U.S. $393/oz)[2] I concluded, on the basis of some early investigations, that the real price of gold would not rise to any significant extent over the long run, but that there was on the contrary some room for further downward correction. In spite of the current upward blip, I see no reason to depart from this conclusion in light of some more recent work. I had mentioned on that occasion that there is, to the best of my knowledge, only one gold forecast that has remained valid over time, and that is the one made by Paul Einzig.[3] He concluded at that time that the price

1. The track record of recent energy price forecasts is highlighted in "Snake Oil Salesmen", by W. Meyer in Policy Review No. 37, Summer 1986, p. 74-77, The Heritage Foundation, Washington. Metal forecasts were reviewed in W. Page and H. Rush: "Long Term Forecasts for Metals: The Track Record, 1910-1960s". SPRU Occasional Paper Series No. 6, U. of Sussex, Brighton, 1978. Methodologies of forecasting are reviewed in W.L. Labys and P.K. Pollak: Commodity Models for Forecasting and Policy Analysis, Nichols, New York, 1984.
2. G. Anders, "Gold Price Forecasting: Some Methodological Considerations", in Precious Metals 1984, I.P.M.I, Allentown, 1985, p. 51-64.
3. P. Einzig, The Destiny of Gold, MacMillan/St. Martins Press, London, 1972, p. 113.

would settle into a range of around U.S. $140 in 1970-71 terms. This would be the equivalent of between $380 and $400 in today's terms (mid-1986).

This paper will not deal with temporary fluctuations, of interest to the trader, but with longer-term constant dollar trends that are of greater interest for purposes of corporate and governmental mineral policy development. In the following I shall touch upon the issue of data accuracy and discuss some pertinent data series covering past production, price and index trends. Most important in this context is the issue of major "breaking points" in long-term trends. I shall comment upon the changing character of gold from predominantly monetary towards common industrial metal status, upon some questions raised by the limits of what Roy Jastram called the "Attila effect"[4] and by the possibility of a shift from inflation to deflation, and finally give some of my conclusions on long range gold price trends under different possible scenarios.

The argument for the proposition of this paper - that the constant dollar, long-term trend of gold prices will be flat to slightly declining, contains four major elements:

- the price history of metals from the mid-1940s to the early 1970s was abnormal;
- industrial metals are necessarily characterized by a long-term downward trend in real prices;
- gold approaches industrial metals in its long-term real price behaviour;
- we can look at long-run metal market trends "as if" real price were an independent variable and supply and demand were dependent variables.

Data and their Reliability

Data on gold production, on gold movements and on gold stocks are notoriously unreliable. The great mathematician and statistician Oskar Morgenstern devoted several pages of his brilliant work, On The Accuracy of Economic Observations,[5] to the subject. Any economic forecaster would sleep

4. Roy W. Jastram, The Golden Constant, Wiley Interscience, New York, 1977.
5. O. Morgenstern, On the Accuracy of Economic Observations, Princeton U.P., Princeton 1963.

much better not having read it and I shall not go into the detail he provides. But there is one crucial - and well-known - set of figures that highlights the problem. Estimates of gold stocks above the ground range from 60,000 to 120,000 tonnes: i.e. potential secondary supply is the equivalent of between 43 and 86 years of production at today's levels. Figure 1 plots annual gold production beginning in 1840, as well as aggregate production (every 5 years). A value for aggregate production prior to 1840 was estimated at about 2,200 tonnes. The value for the end of 1985 of about 93,000 tonnes, lies nicely between the two estimates just mentioned. The actual figure is probably between that figure and the high estimate.

What is immediately apparent is the responsiveness of annual production, over most of the period, to major discoveries and technological innovations. At mid-century there were the California gold rush and the Australian discoveries. Later, the introduction of cyanidization occurred at about the same time that South Africa started producing, and then Yukon and Alaska entered the picture.

Beginning at about 1890, the role played by changes in South African production is clearly apparent. After a short rise there is the trough accounted for by the Boer War, followed by rapid increases in South African and world production, until World War I. This accounts for another trough, followed by a gradual increase until 1930, with rapidly accelerating production after that time. The 1930-40 increase in annual production followed the widespread adaptation of flotation to gold mining in the West and after 1934 the U.S. gold price increase of plus 60 percent. At the same time, however, Russian gold production from the infamous Kolyma goldfields rose to a peak of 300 tonnes in 1940.[6] World War II again sees a tremendous drop-off, particularly in the non-South African production, with increases in South African production beginning in the early 1950s, accounting for most of the runup in production until 1970. The close dependency of changes in total world production upon South African production, until 1970, is obvious and may be highlighted by noting that South African production rose from an insignificant proportion of world production in 1890 to about one-half of world production by 1920, reaching about two-thirds in the early 1960s.

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6. Prof. W.J. Cieslewicz of the Colorado School of Mines estimates the human cost of Kolyma gold production between 1931 and 1957 at 5 to 7 million dead and provides many operating details: "Russia's Bloody Gold", The Phoenix, Aug./Sept. 1986, Toronto, p. 20-22.

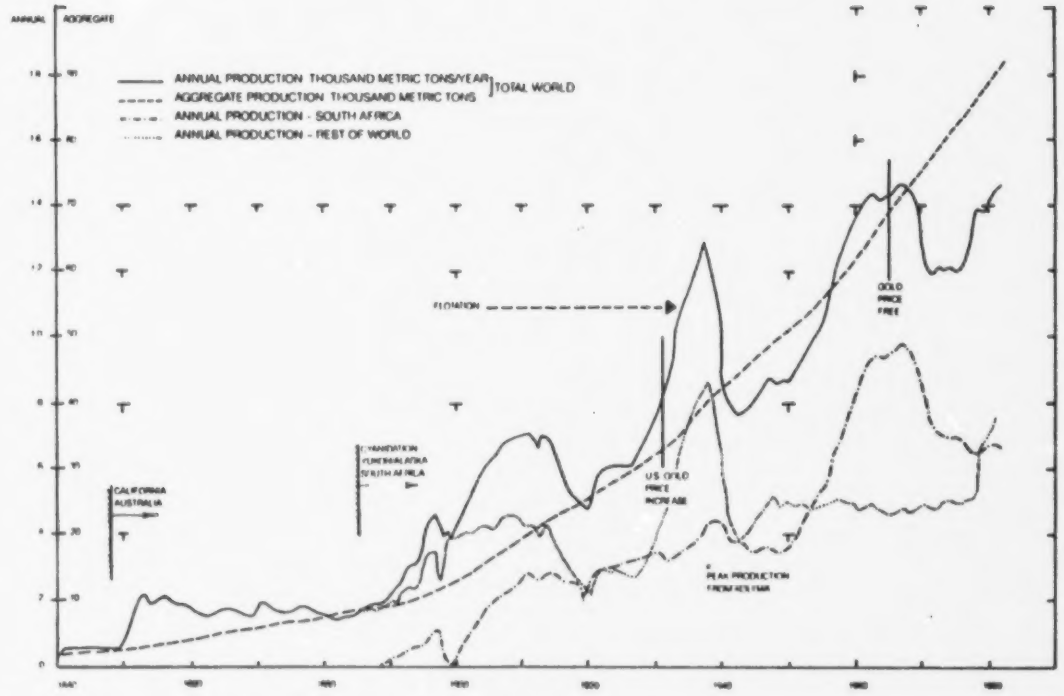

Figure 1. World Gold Production: 1840-1986

While production figures from South Africa and North America are probably reasonably correct, and while Russian production today is at best a rough estimate, production figures from everywhere else, particularly from third world countries, are probably significantly under-reported, quite possibly in some cases by 50 percent or more. As to data on production cost, statistically acceptable series simply do not exist. Physical limits of measurement are another source of uncertainty. To illustrate, Morgenstern[7] reports that in 1960 it was estimated that the total gold stock at Fort Knox could be weighed only with an accuracy of $\pm$ 17 tons. The picture looks even worse when gold movements between countries have to be considered, where accuracies commonly are no greater than $\pm$ 50 percent and are in many cases totally meaningless.

When we come to data on gold prices, the picture is at first sight somewhat better, gold being a publicly traded commodity. Over most of recent history, however, the gold price was fixed - initially guaranteed by the Bank of England (from 1821) at $20.67, and from 1934 by the USA at $35.00. Our experience with a free market gold price is really quite limited, particularly as it is confined to a period that is economically quite volatile.

Indices and Index Trends

It is for this reason that we have to try to draw parallels from the experience of other metals and of the Wholesale Price Index (WPI). If we want to have solid foundations for subsequent quantitative inferences, we must organize available data as best as we can, inadequate as they may be, before modifying our views by qualitative, i.e. subjective, tacit or private knowledge and non-price signals and by applying theoretical considerations.[8] We start with the construction of a metals price index, and comparisons of that with those of silver and of gold. A composite real metals price index (CMI) plotted against the WPI on figure 2 was constructed by converting metal prices into real terms (deflating by the U.S. WPI - 1967 = 100) series by series, converting each series into index form (1967 = 100) and combining these into a composite index. The index incorporates nickel, copper, zinc, lead, iron, silver and aluminum and it is roughly volume weighted by including "new" metals only after they reach some level of maturity and excluding the 1980s silver spike.

7. Ibid.
8. G.P. O'Driscoll Jr. and M.J. Rizzo, The Economics of Time and Ignorance, Basil Blackwell, Oxford, 1985.

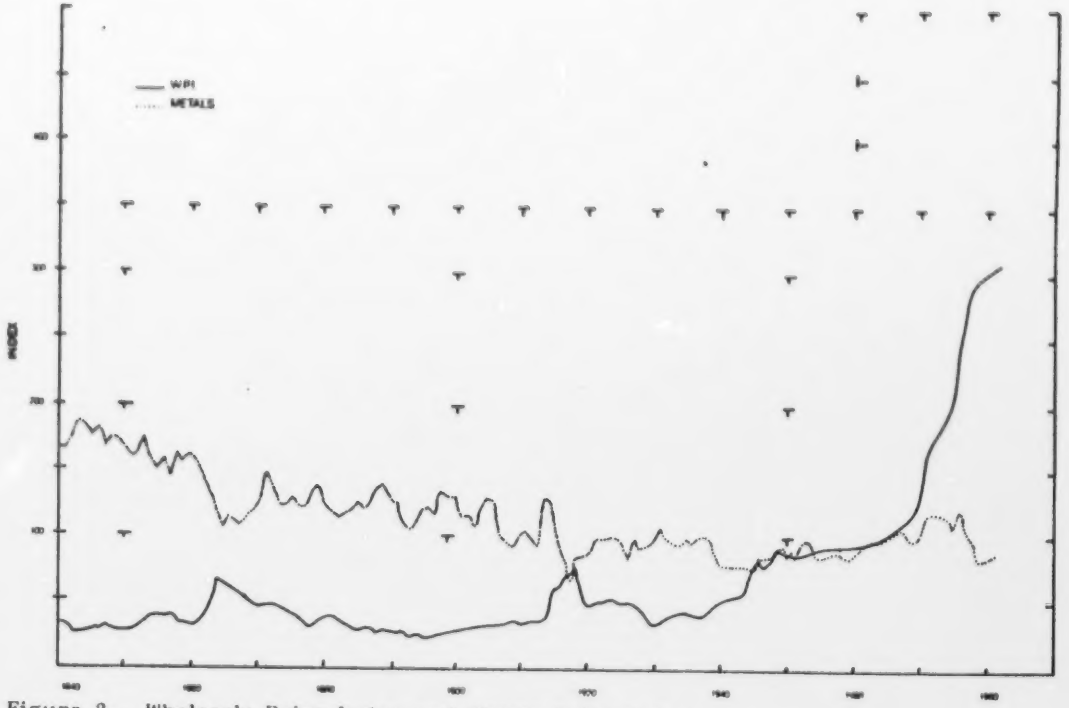

Figure 2. Wholesale Price Index and Metals Price Index

If we next compare this composite real metals price index with the wholesale price index, we see that real metals prices over much of the period covered, present almost a mirror image of the index of inflation as measured by the WPI. In the period 1840 to 1946/47, the WPI is steady to slightly rising and the CMI is steadily declining, with major disruptions - Civil War, World War I - apparent as sharp countermoves. The important period is the second, between the end of War War II and 1970-74. That is the only period over the past century and a half during which both indices rose slowly together. Postwar reconstruction changed into unanticipated inflation. It was this period which has largely shaped the outlook of today's decision-makers and that led many of them astray; without a long-term perspective they could not see how unusual this period was. Predictions drawn only from the experience of these years are still apt to be misleading. Finally, in the period from 1974-77 to 1985, the rapidly rising inflation is reflected in the WPI while the CMI resumes its downward trend. People begin to take inflationary expectations into account; they begin to think in real terms. On the basis of the historical experience, from 1840 to World War I, or that of the third quarter of this century, it had not been necessary for everyday purposes to keep this distinction in mind, and the lessons of the great European post-World-War-I inflation had not been learned or had been obfuscated by Keynesian economics.

Figure 3 compares a gold price index, also on a 1967 constant dollar base, with the WPI and with the CMI. Nominal gold prices are recorded across the diagram but not plotted. The relations among the three indices can be broken down into six major periods. From 1840 to the Civil War period, while the WPI is in a slightly rising trend, the gold index and the CMI are declining, roughly in parallel with one another. From the end of the Civil War to the 1890s with the WPI declining the gold index rises, reflecting this decline, moving significantly ahead of the still declining CMI. In the next period, from the 1890s until 1920, the WPI again begins to rise, initially slowly, then rapidly during World War I. The gold index falls rapidly and returns to the level of the CMI. In the fourth period - the deflationary roaring 1920s - we see gold again moving rapidly ahead, but returning during the (in retrospect) relatively mildly inflationary period from the early 1930s to the early 1970s, to rough equality with the WPI and CMI. In the sixth period, from 1968 to today, after the freeing of the gold price, the gold index rises until 1980 as rapidly as the WPI, while the CMI resumes a downward trend. From the 1980 peak the gold index has retreated significantly,

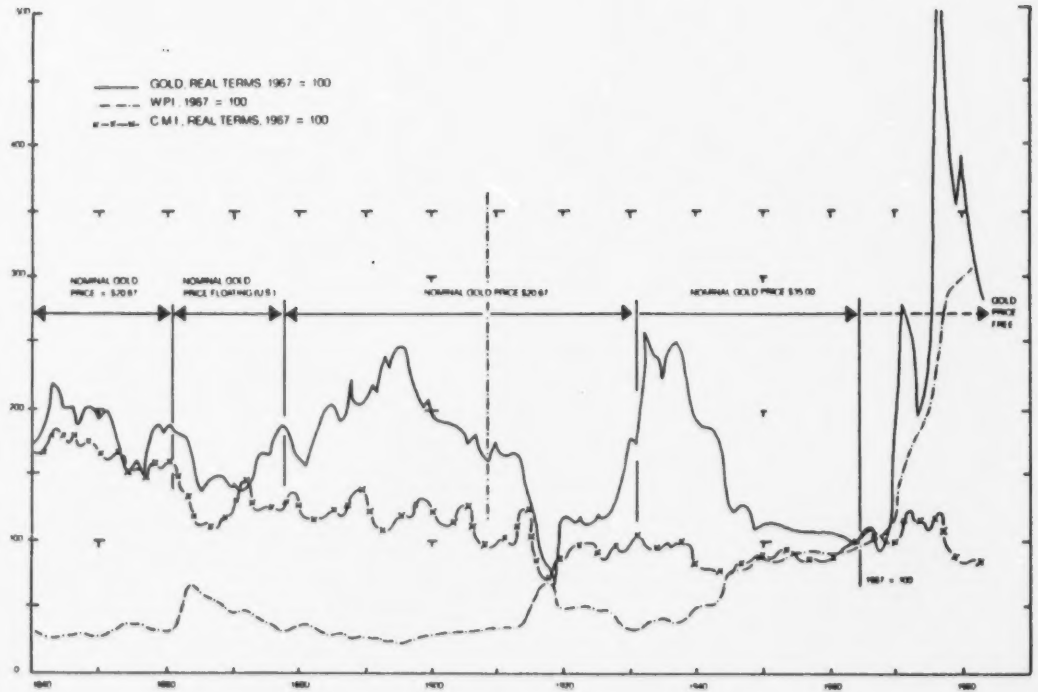
GOLD, REAL TERMS, 1967 = 100
W.P.I., 1967 = 100
C.M.I., REAL TERMS, 1967 = 100
NOMINAL GOLD PRICE = $20.67
NOMINAL GOLD PRICE FLOATING (U.S.)
NOMINAL GOLD PRICE $20.67
NOMINAL GOLD PRICE $35.00
GOLD PRICE FREE
1967 = 100

Figure 3. Index Comparisons: Gold, WPI, CMI

though it is still between 2 1/2 and 3 times the level of the CMI. The recent rise of gold in current U.S. dollar terms will likely turn out from a longer perspective to have been an irrelevant blip.

While the nominal gold price remained fixed, gold as an investment outperformed other metals during deflation and under-performed it during inflationary periods. With the gold price freed, however, it seems that people initially expected this pattern to reverse and indeed, from 1968 to 1980 gold did appear to outperform many alternatives. The lacklustre performance since the 1980 peak came as a surprise to the gold bugs; resumption of the 1968-80 rise continues to be confidently predicted. But such confidence may be quite misplaced.

During the first years of the free gold price, coinciding with periods of very rapid inflation, the gold price in real terms did seem to justify optimistic expectations. This was largely a result of speculative fervour on the part of unsophisticated investors or entrepreneurs, whether individual or institutional. What they did not take into account were:

- the delayed effects of gold price fixing;
- the long-term real price trends of other major metallic commodities;
- the changing mix of gold's monetary and commodity characteristics;
- and lastly, the interactive effects of these three factors.

There is little doubt that, through much of the 19th century, rising gold production was not unrelated to the existence of a floor price. Just as today production levels of certain agricultural commodities are higher with guaranteed prices than they would be in their absence, there is little doubt that gold producers, protected against downside risk by the floor price during periods of increasing real gold prices, increased production in response. Moreover they kept increasing it when the index declined in order to maintain the real value of their revenue, and also actively pursued technological progress and geological discovery to boost output.

Figure 4, relating gold production to the gold price index and to the rate of inflation, shows annual production to be reasonably stable from 1850 to the 1880s, a period of reasonably stable gold price index, then production rising with rising index until 1900, rising with falling index until World War I, and after falling with falling index during the post World War I recession, production rising again with

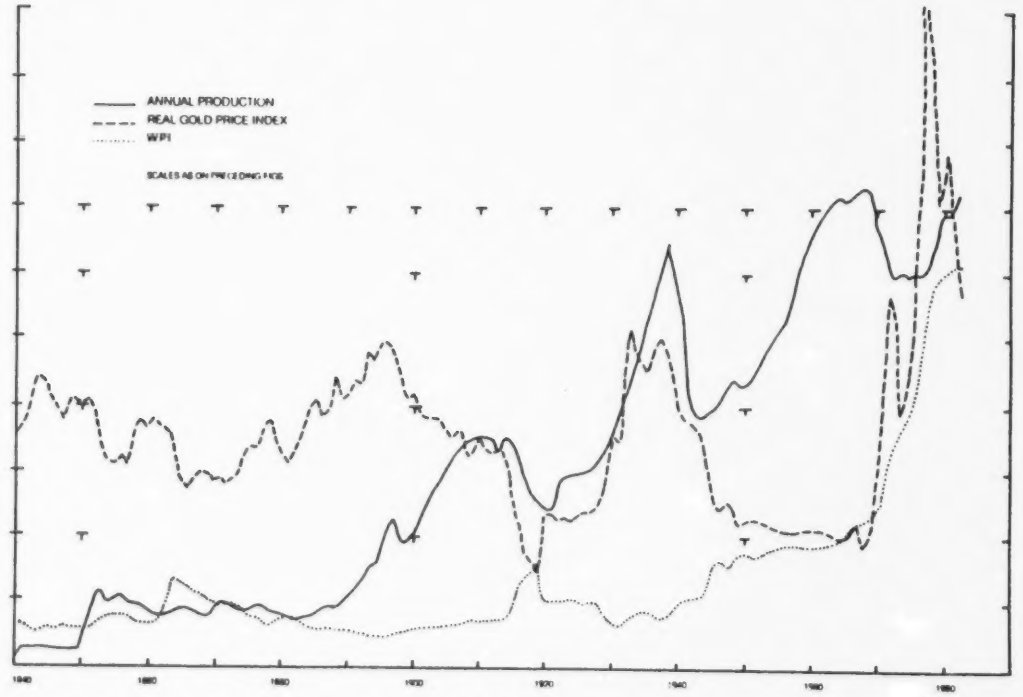

Figure 4. Gold Production, Price, Inflation

rising index until the beginning of World War II. After the decline during World War II in both production and real price index, production increases with a stable index until the freeing of the gold price. After a brief decline of production with a steeply rising index, and a few years in the mid-seventies of fairly stable production with rising index, production rises again against a falling index. One may suspect that the steeply declining index since 1980 is a major delayed effect of the artificially high production during the century and a half of a gold floor price, maintained first by Britain and then by the United States.

It is difficult, maybe even impossible, to estimate how the real gold price would have behaved over time if there had been no price maintenance. To arrive at any conclusion as to how the gold price in relation to other prices may perform in the future, we might draw some lessons from comparisons of the behaviour of the gold and silver index, of the silver index and the CMI and of the silver index and the WPI. (Figures 5, 6, and 7) The first comparison between the gold and the silver index suggests that both metals, though one was price supported and the other not, behaved in quite similar fashion - with the exception of the gold floor price increase in 1934. The second comparison, between the silver index and the CMI (figure 6), shows how over time silver has come to resemble other metals rather closely. Again, we have the speculative breakout of 1980. The correlation coefficients for the CMI show the good fit of simple straight line trends. The most important for the analysis of future patterns are those for 1840-1947 and 1840-1985, the ones for 1974-85 representing a correction for the 1947-74 aberration. With gold's behaviour over the time being similar to that of silver and silver's to that of base metals, we have some logical reason, on statistical grounds, to expect gold to increasingly approach the CMI in its long-term real price behaviour.

Figure 7 gives for a much longer period a comparison of wholesale price indices and the silver price index. It is a picture that extends the mirror image of figure 2. This comparison can, I think, support the conclusion that silver has by and large behaved as have other commodities and that in the absence of discriminatory price supports, distinctions between precious (monetary) and base metals or even commodities in general should not be overplayed as far as their long-term real price behaviour is concerned. If gold is going to share to an increasing extent in the characteristics of other metals, we may expect that, on the basis of such historical data as we could cover, the real

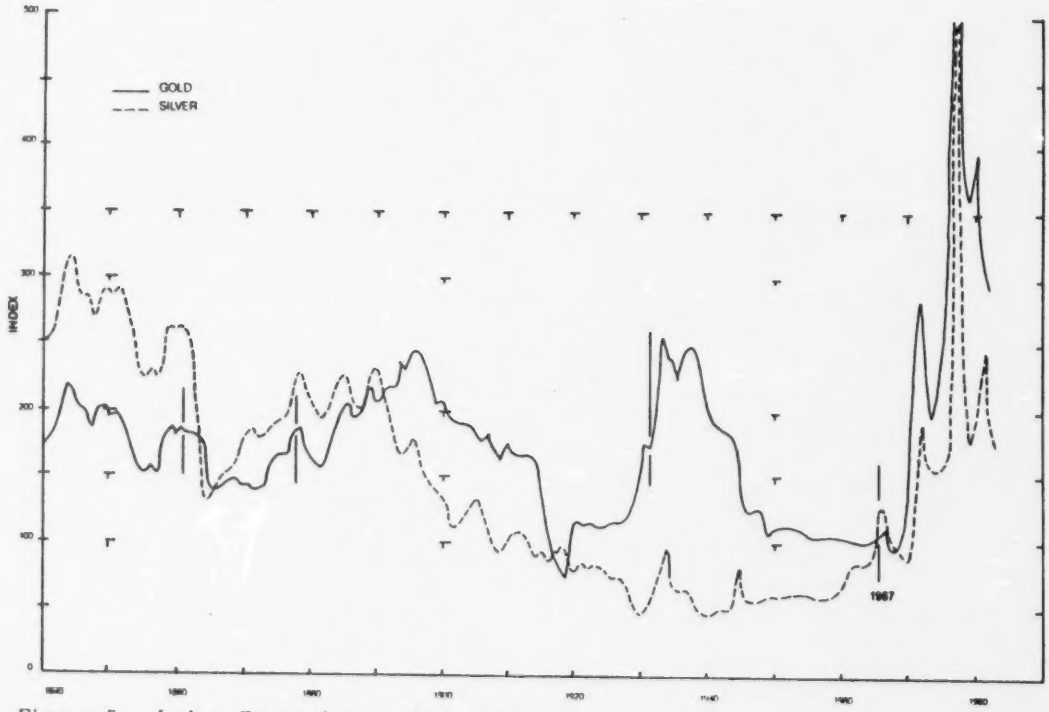

Figure 5. Index Comparison: Gold, Silver

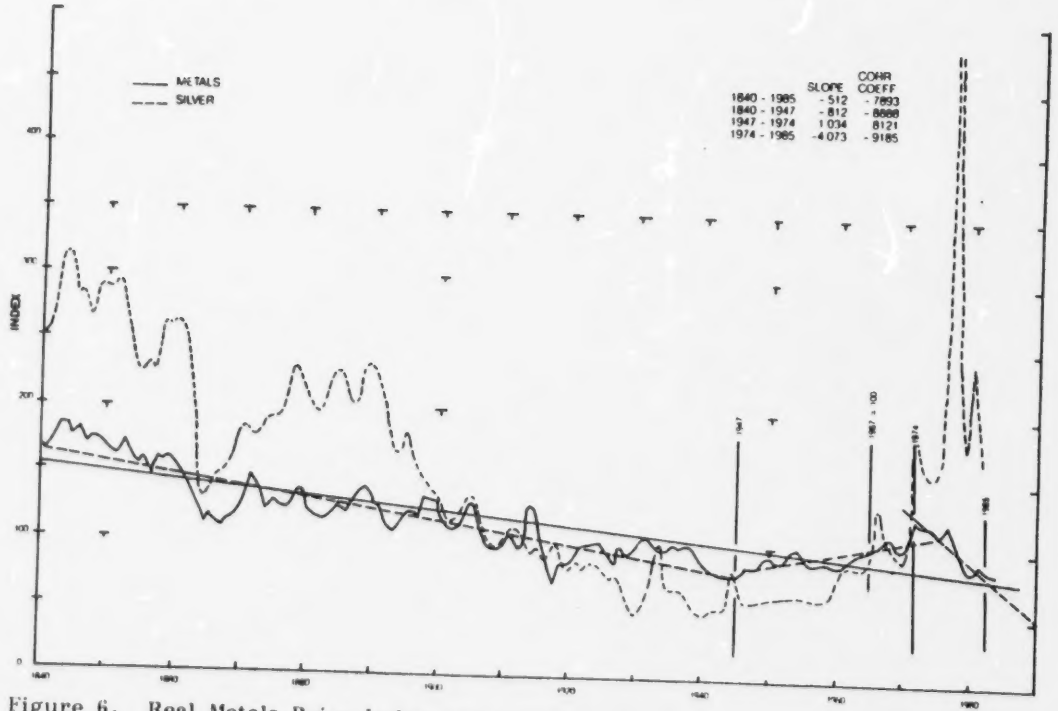

Figure 6. Real Metals Price Index and Trends

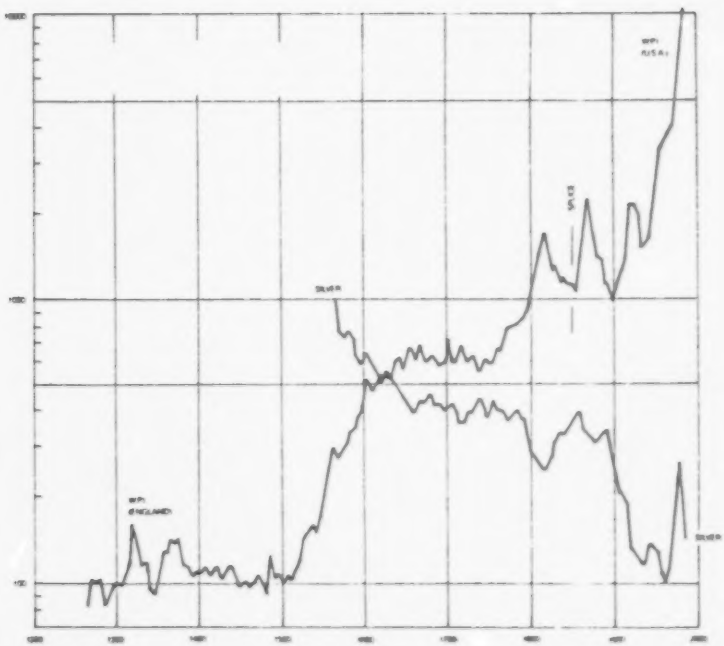

Figure 7. Long-Term Price Movements

price of gold will over the long run partake in the flat to slightly declining secular trend of all other metals. Over shorter periods, speculative movements for gold as well as for silver will continue to be more pronounced than those of other metals.

The long-term patterns discussed might suggest that, with respect to metals, it is not supply and demand that determine long-term price trends, but that price is an independent variable, which in turn determines supply and demand. It is not asserted here that such is the case. What is involved is a generic rather than a particular aspect of mineral commodity markets.[9] We can, in light of the problems surrounding supply, demand and cost data, approach metal price projecting "As If" it were the

9. Northrop, F.S.C., "The Impossibility of a Theoretical Science of Economic Dynamics"; Q.J.E., November 1941.

case10. Our standard supply and demand diagram evolved from the observation of local, small and relatively isolated markets for a few consumable agricultural products subject to spoilage. But metals don't decay, they are not consumed but only transformed, they trade on worldwide markets and the definition of "product" is constantly expanding. The issue recalls the difficulties exposed by the economic analysis of antitrust legislation in definitions of product, market area and market share.

One could suggest an alternative explanation in which the downward trend is supply driven. But, in light of the trend's long-term consistency, while both supply and consumption were steadily rising, one may doubt whether supply and demand factors can explain more than very short-term fluctuations around this long-term trend. Further, for a supply-driven explanation over such a long time, we would have to make some strange assumptions, among others that over five or six generations mining entrepreneurs never learned from experience or from history, again and again overshooting the mark. A plausible and general explanation of this apparent departure from traditional textbook economics is supplied if we shift our focus from physical commodities to the services they provide.

Commodities and their Services

Precious and base metals, just as any other commodities, provide services due to their characteristic combinations of technical and locational properties. These in turn satisfy to a greater or lesser, but never to a perfect, extent demands for particular services on the part of consumers, and these relationships at a given time define the economic properties of the commodity. While on the one hand, most commodities hardly ever possess the ideal characteristic mix sought by a consumer for a specific purpose, on the other hand there are usually a number of commodities that can meet a broad range of consumer demand specifications reasonably well. Technological progress keeps increasing the number of commodities that compete for such demands; what is true for the mix of technical properties sought in most metals is true for the mixture of technical and economic properties sought for in money.

10. Vaihinger, H., The Philosophy of "As If", Barnes & Noble, New York, 1968.

What are some of the conditions that would have to prevail for a secular increasing real price trend for a specific mineral commodity to develop? We have to ask whether such criteria can be met by gold, or for that matter by any other metallic mineral commodity.

The hypothetical commodity would not only have no current substitutes, but it would also be impossible for substitutes to be developed in the future. There would have to be an absolute, vital and widespread need - not just a want or a desire for this commodity; changing taste or fashion would not affect it. It would be in absolutely fixed supply, which would have to be totally exhaustible within ordinary planning horizons of 20 or 30 years. Lastly, it would not be recoverable from scrap; i.e. it must be impossible to shift units of such a commodity from being embodied in current uses to higher valued uses by reprocessing. Clearly no metallic mineral commodity - in fact, no commodity at all - does or conceivably can ever meet these criteria.

Historically, many commodities provided money services. In this day the statistical definition of money (as in money supply) is anything but non-controversial. The reason why over long periods of time and over many parts of the world gold was preferred as money (but the argument applies to other commodity moneys) has been put by Irving Babbitt:

> The reason for the gold standard is simple: gold involves in its production an amount of work equal to the amount of work involved in producing the various commodities for which it may be exchanged. If for any reason gold is produced more abundantly and with less effort, of if the reverse takes place the monetary standard fluctuates and this is an evil, but a trifling evil, (human nature being what it is) compared with that which results from substitution for gold of paper or some other medium of exchange, that when tested in terms of work has little intrinsic value.[11]

We must, however, guard against over-interpreting the implications. Acceptance of Babbit's argument does not require us to assume expansion of the use of physical gold

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11. Irving Babbit, Democracy and Leadership, 1924. Liberty Classics, Indianapolis, 1979.

to cover people's small daily transactions - under a rule of law. In fact, the more people feel assured for the long run of their freedom to own, buy and sell gold unmonitored by government and to write gold clauses into their contracts, the more confident they are that they are secure in their property against political upheaval, the less may they well avail themselves of the opportunity to shift larger proportions of their assets into gold.

It was that expected inflation protection which made, in many parts of the world during the rapid inflation of the post World War I and II periods, gold a preferred store of value - that and the Attila effect.

The core argument that could make inflation in its turn the preferred popular policy option, was well put by Rees-Mogg: "With stable money you have to be creative, with inflation you only have to be clever or lucky and clearly most people would rather rely on cleverness or luck than creativity or "productivity".[12] How indeed the forces that favour inflation can become dominant, has been persuasively analyzed in highly readable detail by Freeman Tilden.[13] People soon find out that, with cleverness or luck, gains from inflation can be made by investing in assets which outperform gold, that in other words there were other things which provided some of the particular monetary services that some people had sought in gold to a greater extent. T.R. Saving has provided an excellent and concise analysis of the role of gold in an "efficient" investment portfolio[14] (no higher expected rate of return without increased risk, no lower risk possible for given expected rate of return). His conclusion was that such a role would be limited because, on the historical evidence and on the basis of inflationary expectations (assuming monetary base growth less than 8 percent p.a.), expected returns would be inadequate and because risk factors are too high with governments holding stocks nearly twice as large as private investors' stocks.

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12. W. Rees-Mogg, The Reigning Error, Hamish Hamilton, London, 1974.
13. F. Tilden, A World in Debt, New York, Funk and Wagnalls, 1936; Re-issue: Toronto: Friedberg Commodity Management, 1983.
14. T.R. Saving, "Gold and Gold Mining Stocks in your Personal Investment Portfolio", Precious Metals 1984, I.P.M.I., Allentown, 1985, p. 81-89.

Base Period Choice and "Breaking Points"

While the extrapolations of price trends I have used are in the flat to declining range, it should be obvious that the choice of different time periods and of current or constant dollar price data can affect the results in a major way. Table 1 illustrates the point. Among the choices given there, changes in the price of silver range from -50.9 percent to -1227.4 percent and of gold from +7.3 percent to +1643.6 percent. For the purposes specified in the beginning and recalling figure 6, this is an argument for choosing longer rather than shorter periods and constant rather than current terms as bases for extrapolation.

When looking at economic data or events and trying to predict future developments, our mindset has by and large been shaped by the experiences of this century, and some of us may recall from our readings some data and some trends or technical or economic developments of the 1800s. But when it comes to the assessment of future inflationary expectations, such foundations may be dangerous to build upon. Figure 8 illustrates the very long-term path of inflation. There has only been one extended period, the Tudor inflation in England, which is comparable with the inflationary experience of this century, although a shorter such period had in the interim characterized the sequence of the Seven Years' War, American Revolution, French Revolution, and Napoleonic Wars. The diagram shows five major breaks in trends: three from long-term deflationary to long-term inflationary periods and two from long-term inflationary to long-term deflationary periods.

The key concept here is that of "breaking points" between flat to declining and rapidly accelerating trends or vice versa, each lasting a century or more. This is longer than any corporate or personal memories. It suggests some inverted "expectations theory": The unlearning of lessons of history, an it-can't-happen-again/it-can't-happen-to-us syndrome. What does seem to jump out of this diagram of the historical record of inflation is that the possibility of another long-term flattening-out, occurring within the next decade or two, cannot be dismissed. It implies that any extrapolations from experience, whether in the form of diagrams or of theories, have to be modified by a consideration of what might happen if we move again into a long period of deflation. There are some indications that this may indeed be the case, and the possibility has been mentioned by some analysts. It would suggest to me the necessity of stressing the already downward trending forces, and even further modifying downward real price projections for

Table 1

EFFECTS OF CHOICE OF TIME PERIOD AND CURRENT OR CONSTANT TERMS ON PERCENTAGE CHANGES IN U.S. $ METAL PRICES

	Real Metal Price Index	Nickel c/lb	Copper c/lb	Zinc c/lb	Lead c/lb	Iron $/lt	Silver c/oz	Aluminum c/lb	Gold $/oz
1947-72									
Current Terms		35	21.6	10.50	14.67	33.82	71.82	15.00	35.00
		134.5	46.5	17.76	15.03	80.15	168.46	26.41	58.44
Change (%)		+284.3	+115.3	+69.1	+2.5	+137.0	+134.6	+76.1	+67.0
Constant Terms	72	46	28.74	13.72	19.18	44.21	93.88	19.60	45.75
	99	113	39.04	14.91	12.62	67.30	141.44	22.10	49.07
Change (%)	+37.5	+145.7	+35.4	+8.7	-34.2	+52.2	+50.7	+12.8	+7.3
1900-1984									
Current Terms		50	16.5	4.40	4.41	19.98	61.33	32.77	20.67
		233	66.9	48.60	25.55	238.56	814.07	81.00	360.40
Change (%)		+366.0	+305.5	+1004.5	+479.4	+1094.0	+1227.4	+147.2	+1643.6
Constant Terms	131	173	57.09	15.22	15.26	69.13	212.21	113.22	71.52
	88	72	21.72	15.78	8.30	77.45	264.3	26.20	117.00
Change (%)	-32.5	-58.7	-62.0	+3.7	-45.6	+12.0	+24.5	-76.9	+63.6
1840-1985									
Current Terms		170	24.50	7.00	4.39	32.75	132.38	58.66	20.67
		227	66.80	42.80	19.05	233.79	616.00	80.00	317.27
Change		+33.5	+172.7	+511.4	+333.9	+613.9	+365.3	+36.4	+1435.0
Constant Terms	167	507	73.13	16.83	14.6	97.76	395.16	232.78	61.70
	89	72	21.21	13.59	6.05	74.22	194.00	25.40	100.72
Change	-46.7	-85.8	-71.0	-19.3	-58.6	-24.1	-50.9	-81.1	+63.2

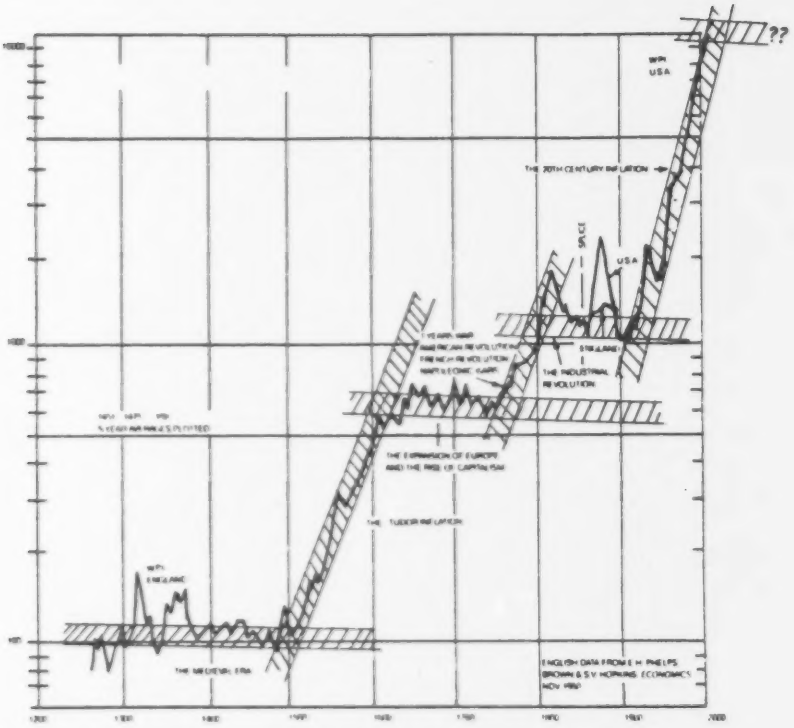

Figure 8. The Long-Term Path of Inflation

gold and for other metallic commodities derived from the time series discussed.

In the context of "breaking" points, now within a somewhat shorter time frame, a question may also be raised as to how a recent major discontinuity, such as appears about 1970 in the 1840-1985 index diagrams, may be dealt with.[15] It clearly prohibits "mindless", purely mechanistic extra-

15. Such modifications with respect to some base metals were discussed in Towards a Nickel Policy for the Province of Ontario, Mineral Policy Background Paper no. 4, Ontario Ministry of Natural Resources, Toronto, 1977, p. 13-38; The Future of Nickel and the Law of the Sea, no. 10, 1980, p. 15-16; World Mineral Markets, Stage II, no. 14, 1981, p. 105/607 and 217-224.

polation. It highlights the need for a thoroughly subjectivistic critique of much conventional modeling - acceptance of the principle that intelligibility is more important, if more difficult to achieve, than deductibility[16]. A mechanistic extrapolation must be modified, corrected, by subjective assessments particularly of non-market factors. Pursuit of this topic however would carry us too far, for our present purpose, into some of the most troublesome methodological controversies of economics. As to the concrete question, we may suggest that the 1970 discontinuity was essentially the result of a last attempt at Keynesian, that is inflationary, demand management that has now run its course.

This leads to one last follow-up question that might arise: whether the non-market factors in light of which trends have to be modified (we are essentially speaking about government policies), are the agents or themselves the results of economic changes. At other times and places, governments may have been the victims of economic change. Here and now they are most likely predominantly the agents. Again, it is a problem that would carry us too far here. I have tried to deal with it elsewhere[17] in a general mineral policy context and the most recent issue of The Cato Journal,[18] devoted to "the rent seeking society", provides an excellent up-to-date overview.

Summary and Conclusions

Earlier on, four often neglected factors were mentioned as having significant bearings on the long-term future trend of real gold prices.

1. The effects of the tremendous capacity built up as a result of a century and a half of guaranteed floor prices and further boosted by the 1980 speculative

16. G.P. O'Driscoll, Jr., M.J. Rizzo, The Economics of Time and Ignorance, p.26.
17. G. Anders, "Mineral Title, Land Use Allocation and Mineral Investment" in Selected Papers on Mineral Economics, Mineral Policy Background Paper No. 22, Ontario Ministry of Natural Resources, Toronto, 1985, p. 93-123.
18. The Cato Journal, vol. 6, no. 1, Spring/Summer 1986, The Cato Institute, Washington.

boom, with the bulk of production accumulated in government hands, have not yet worked through the market under a free gold price regime. Major banks and governments have not yet really begun to reduce their holdings of prospectively sterile assets that would be depreciating under deflationary conditions.

2. To the extent that gold will in its real price behaviour increasingly approach the pattern of other metals, it will be subject to the same secularly downward trending forces which all commodities must obey in the long run.

3. There is an increasing menu of competitive moneys and near-moneys, and there is increasing recognition of gold's lack of attractiveness as a major component of an efficient investment portfolio. The mix of gold's monetary and commodity characteristics is going to change increasingly towards the latter - a fate, incidentally, to which other commodity moneys in history have succumbed. This is not to deny that some of gold's monetary role will continue, even perhaps increase, and that bullion coin sales in the West and in North America may even increase significantly.

4. With all of these three factors being bearish, their combined effect can only be bearish as well.

The Attila effect has probably worked itself out or at least reached some equilibrium in Europe and some developed parts of Asia. Its potential in North America is severely limited and, in the case of cataclysmic political change in the USA, there would be no place left to run with one's gold hoard.

Gold is being freed increasingly from remaining legal and political constraints. Paradoxically, the greater the freedom to use gold as alternative money, the more efficient it is likely to be over time in constraining inflation, and the cheaper it is likely to become. Alternatively, the real price of gold would be bound to rise the more its ownership and use is interfered with by government.

We may extend an argument developed by Jastram, that it was the great productivity increases over the last few centuries, due to the combined effects of the industrial revolution and generally increasing political stability, which contributed to the amazing long-term stability of gold's purchasing power. Productivity increases of such magnitude in the future assume an increasing stability of cap-

italistic institutions - concretely, a retreat from current extensions or at an absolute minimum no further extensions, of redistributive invasions by government of private property rights. Major moves further along the path towards socialization with attending necessary negative effects on general productivity growth, particularly if not offset by expansions of the underground economy, would tend to increase the ratio of gold to goods produced, while moves in the opposite direction, reducing the fear of government intervention in the economy would tend to decrease this ratio.

We have really only two basic scenarios. In one the recent trends are continuing pretty much as they are. Under such current trends in the direction of a) further contraction of government activities in the developed Western World, and b) further unshackling of the capitalistic system, coincident with a long-term period of deflation, we can quite confidently predict declining real price trends under a continued regime of private ownership and possibly even private minting of gold. The other scenario is the only one under which, at least for a time, gold prices would rapidly increase in real terms over an extended time period, i.e. longer than the one- to three- to five-year essentially speculative spikes that have characterized recent years. It would be based on the expectation of inexorably accelerating inflation over at least another decade, in turn implying eventually a complete economic and political collapse throughout the world: a scenario, in other words at the end of which all bets would be off.

On the bottom line, my own bet would be a shift within the next decade to a long-term deflationary scenario with relatively high real interest rates, coupled with extremely tight credit markets discriminating on the basis of true creditworthiness. This would be based upon an increase in the political momentum, personified today by Prime Minister Thatcher and President Reagan towards the reduction of the role of government in the economy via intervention and in the private lives of citizens via taxation. This results inevitably in a long-term slightly declining real price trend for gold and other metallic commodities.

GOLD EXPLORATION: IMPACT OF CHANGING GEOSCIENCE CONCEPTS AND TECHNOLOGIES

Roy Woodall

Introduction

Gold has been treasured since ancient times for its permanence, beauty and convenience as a means of storing and transferring wealth. Recently, it has emerged as an essential industrial metal.

The earth's crust is estimated to have an average gold content of 3.5 ppb (0.0035 grams per tonne), the average gold content of common rocks being 1.5-7 ppb. It thus requires processes capable of concentrating gold 500 to 2,000 times above its crustal abundance to form an orebody.

Gold mining has been an industry of mankind for almost 6,000 years. The earliest gold miners were the Sumerians, who were working deposits in present-day Iran by 3800 B.C., and the Egyptians who, by 3500 B.C., had organized gold mining on a significant scale.[1] Figures produced by Thomas and Boyle[2] suggest that total world production to the end of 1985 was about 125,000 tonnes.

Gold production in the Western World in 1985 was 1,212.8 tonnes (table 1), an increase of 267.1 tonnes in ten years, and it seems set to increase almost as much again by 1990. Five regions - Canada, USA, Australia, the Pacific Ocean rim and Brazil - are major contributors to this increased production. The gold potential of Canada is the subject of a separate presentation in these proceedings and will not be considered further in this discussion.

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1. J.R. Poss, Stones of Destiny: A Story of Man's Quest for Earth's Riches, Michigan Technological University, Houghton, Michigan, 1975.
2. P.R. Thomas and E.H. Boyle, Gold Availability - World: A Minerals Available Appraisal, United States Department of the Interior, Information Circular 9070, 1986, p. 6.

Table 1

GOLD PRODUCTION IN THE WESTERN WORLD
(tonnes)

	1975[1]	1985[1]	Growth 1975-1985	Early 1990s	Growth 1985-1990s
South Africa	713.4	673.3	(40.1)	710	37
Canada	51.4	86.0	34.6	115[2]	29
USA	32.4	79.0	46.6	140[2]	61
Australia	16.3	57.0	40.7	120	63
Latin America	29.6	99.4	69.8		
Western Pacific	43.7	86.3	42.6		
Total Pacific Ocean Rim	73.3	185.7	112.4	230	44
Brazil	12.5	63.3	50.8	75[3]	12
Rest of West. World	46.4	68.5	22.1	80	12
Total	945.7	1212.8	267.1	1470	258

Sources: [1] G. Milling-Stanley and T. Green, Gold 1986, Consolidated Gold Fields PLC, 1986.
[2] W.F. Beunderman, Western World Gold Production, Consolidated Gold Fields PLC, London, 22 July 1986;
[3] P.C.D. Burnell, Brazil in the World Gold Business, Presentation to Financial Times "World Gold in 1986" Conference, London, June 1986.

Increased gold production in the five regions reflects not only geological opportunity, i.e. endowment and successful exploration, but also the price of gold in domestic currencies. Figure 1 shows how gold production in these regions has benefited from real depreciation of currencies against the U.S. dollar.

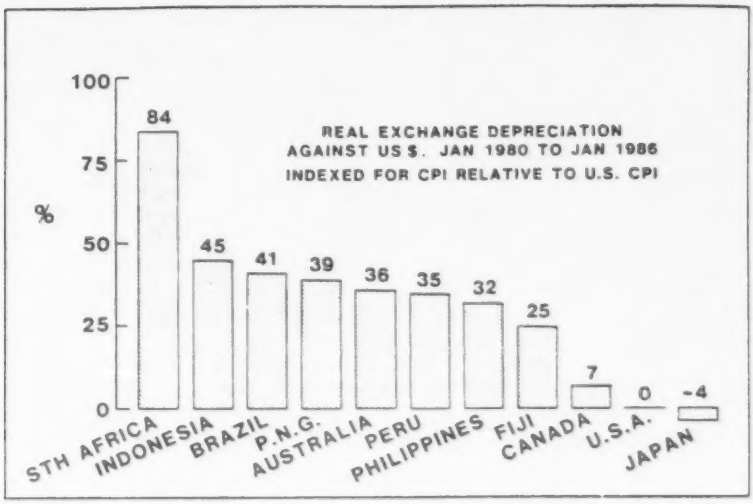

Figure 1. Gold Producers Relative Currency Depreciation

New Concepts and Technologies

The increased price of gold and spectacular gold discoveries - like Hemlo in Canada, Hishikari in Japan and McLaughlin in the United States - have combined to create a worldwide renaissance of interest in the occurrence of gold and the science and technology of gold exploration. Scientists in government organizations, universities and mining companies are taking a renewed interest in how nature concentrates this metal into economic grades, and how and where new, economic deposits might be found, creating the most concentrated research effort the gold industry has ever known. As information on new exploration concepts and exploration technology is commercially sensitive and often of a proprietary nature, time must elapse before we will fully appreciate the nature and significance of the advances that are being made. It is safe to say, however, that major advances are being made.

Nevertheless, there is still much to learn about how best to explore and where. Why is there so much gold in the Witwatersrand Basin? Why is so much gold found associated with the igneous rocks which formed on the earth at approximately the same time as the Witwatersrand Basin? Why did 2,500 million years elapse before igneous activity in

the late-Mesozoic and Tertiary was again associated with the formation of a large number of gold deposits (figure 2)? Why are the major deposits, which are small in comparison with the extent of favourable rocks and minute in comparison with the earth itself, located where they are?

Geologists and chemists are now extending our understanding of the possible sources of gold within the earth, its mode of transport and precipitation from solution to form ore deposits. New gold discoveries will unquestionably result from this research and some discoveries will be "giant" deposits, i.e. in the range 500 to 5,000 tonnes of contained gold.[3] Whether any of these new discoveries will be "super giant" deposits of 5,000 to 50,000 tonnes is impossible to predict.

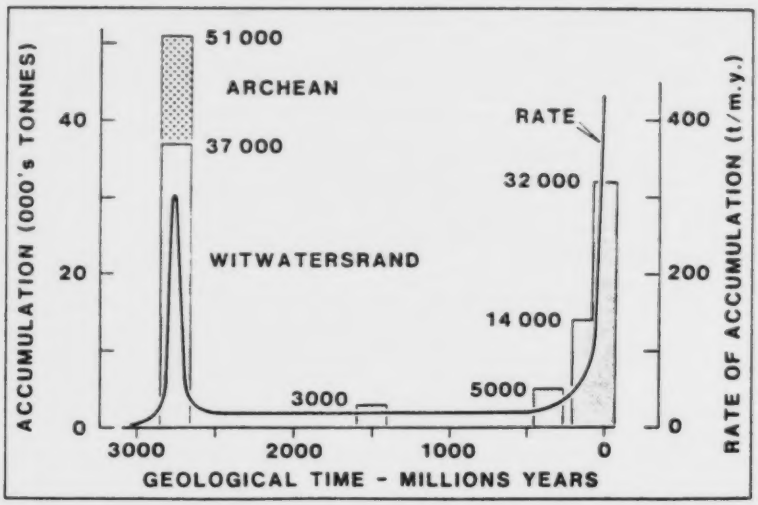

Figure 2. Gold in Geological Time

3. P. Laznicka, Giant Ore Deposits: A Quantitative Approach, Global Tectonics and Metallogeny, vol. 2, nos. 1 and 2, 1983, pp. 41-63.

Advances in our understanding of the physics and chemistry of gold-bearing epithermal systems, in many cases aided by the documentation of their modern analogues, the geothermal systems, have been significant. It is now possible to interpret field and laboratory observations in terms of temperature, pH, CO_2 activity, boiling, changes in redox potential, solution and gas transport, likely geometry and level of exposure. This will unquestionably aid exploration.

Exploration geochemistry is an area where there have been significant advances in gold exploration technology. As a result of the development of extremely sensitive analytical techniques, it is now possible to measure cheaply, and thus routinely, a few parts per billion (ppb) of gold in soils, sediments and rocks. This enables a much clearer definition of subtle but significant anomalies of as little as 5-20 ppb which in turn have led to the discovery of new, economic gold deposits.

The vertical and lateral movement of gold in deeply weathered terrains is now better understood. In these environments geochemical anomalies related to gold mineralization tend to be enhanced in areal extent, even though gold may be strongly leached in the weathering profile. Moreover, although geochemical dispersion is dominantly associated with the downwards leaching of gold, in some environments sufficient gold migrates upwards over sub-cropping mineralization to form geochemical anomalies in transported overburden such as windblown sand and younger sedimentary cover.

In geochemical reconnaissance, the use of heavy mineral concentrates from stream sediment samples is giving way to the analysis of the finer sediment fractions for low-level gold. Multi-element data, made available by modern analytical techniques, is also being used to study primary dispersion and the zoning of elements around economic concentrations of gold. As our ability to manipulate and interpret low-level gold and multi-element data increases through the use of modern computers, new avenues for exploration will undoubtedly emerge and the targeting of mineralization which does not outcrop will be more common. We will also become more skilled in recognizing "near-miss" drill holes in exploration programs.

Geophysics has a great deal to contribute to gold exploration, even though its value is usually indirect, serving mainly to aid surface and sub-surface mapping of lithology, structure, associated mineralization and alteration zones. Magnetic, electrical and electromagnetic methods have the greatest application in geophysical mapping. The Hishikari deposit in Japan was discovered thanks to a helicopter-borne electromagnetic survey which detected response from

the enhanced electrical conductivity of clay zones associated with the gold mineralization.

In the past ten years, the advent of micro-processor controlled instrumentation for data acquisition and navigation has materially improved geophysical data quality. The alkali vapour magnetometer, with its fast sampling rate and high sensitivity, in conjunction with improved navigational systems, has introduced a new degree of precision into detailed, low-level, aeromagnetic surveys. At the same time, rapid advances in computer hardware and software have facilitated data manipulation and interpretation and the visual presentation of the results of surveys through the use of image processors. Visual presentation is particularly effective in highlighting subtle features which might be missed on traditional contour plans or stacked profiles.

Geophysics is thus poised to play an increasingly important role in exploration for gold, especially in poorly exposed regions or where access is difficult. The trend in geophysical acquisition is towards more and more precise measurement of a more and more extensive repertoire of physical properties. One likely future development is improved electronic monitoring of airborne sensor motion, rendering airborne gravity and three component aeromagnetic and electromagnetic systems practicable. The signal-to-noise ratio will continue to improve as a consequence of further refinements in signal enhancement. New geophysical systems are also likely to be developed, e.g. methods based on the piezo-electric property of quartz and seismic systems.

Ore deposits are discovered and evaluated with drills, and improvements in the cost of drilling and the reliability of the samples generated have both been significant. Many recent gold discoveries can be attributed to these improvements, especially to the development of reverse circulation percussion and rotary drilling.

Depletion and Discovery

Each orebody mined is one orebody less, but it is simplistic and quite erroneous to conclude that mining necessarily means there will be a significant depletion of economic mineral resources. Ore deposits are easily hidden in the earth's surface, which is vast in comparison with the size of the deposits. Large numbers undoubtedly remain to be discovered.

Exploration to date has been ineffective in many areas, especially below a few hundred metres of the surface.

Moreover, an ore deposit is defined in economic terms, so that any increase in price, as well as improvements in mining, milling and extraction techniques which reduce the cost of metal recovery, will increase the number of available economic deposits. This is particularly true in the gold mining industry where price increases, the development of carbon-in-pulp (CIP) and carbon-in-leach (CIL) extraction technology and heap leaching have created a great deal of new ore. There is much evidence to suggest that the depletion of mineral resources is more the result of poor government policies than mining.

Whether the current renaissance in the science and technology of gold exploration will have the impact of which it is capable will depend a great deal on the profitability of the gold mining industry, which in turn will depend on a number of economic factors, the three most important being:

- the gold price in the domestic currency of the producing nations in relation to production costs;
- corporate management policies;
- the taxation policies and regulatory mechanisms of governments.

Despite the excellent potential for new, major gold discoveries, increasing understanding of gold occurrence, and improvements in exploration technology, the cost of making major discoveries will be substantial. Thus, if governments see the current profitability of the gold mining industry as simply an opportunity to harvest a short-term but rich reward through taxation, there will be insufficient finance to support vigorous exploration for the more difficult-to-find deposits. There will be insufficient incentive for investors to undertake the high risk. If management, for its part, is more concerned with paying excessively large dividends than maintaining long-term financial support for exploration, there may also be insufficient resources for exploration, especially as the undiscovered ore deposits are unlikely to outcrop and will be more difficult and costly to find than those in present production. Both management and government must be conscious of this when they set their strategies and policies.

At what cost might new discoveries be made? Most of the large, undiscovered, gold deposits are likely to be concealed by soil, transported overburden or younger sediments, or outcropping in remote or inhospitable terrain. Such deposits will not be easy to find and we can expect that over the next decade or so, each significant new gold discovery will cost in the order of U.S. $30-$50 million.

The discovery of world-class gold deposits, containing in excess of 100 tonnes of gold, may cost in excess of U.S. $200 million, i.e. perhaps as much as $60 per ounce. These estimates are based on the cost of discovering economic metal deposits in Australia during the 24-year period, 1955 to 1978.[4]

Gold exploration has significant economic advantages over exploration for other metals, as, at this time, even small discoveries can be profitably mined due to the relatively low capital cost involved, the high gold price, the ease with which the product can be sold, and the speed with which discoveries can be brought into production. Thus, even small discoveries can significantly influence the economics of investing in gold exploration even though they may not contribute substantially to total world gold production.

Endowment and Exploration Opportunities

The periods during earth's history when gold deposits preferentially formed are shown in figure 2 and the locations of main deposits in figure 3. The Archean period between 2800 and 2600 million years (MY) was the most favourable for the concentration of gold. This was when the vast gold deposits of the Witwatersrand Basin formed, from which a third of the world's gold has been produced. The gold in Archean volcanic rocks is of a similar age. By contrast, the period 2600 MY to 500 MY seems to have been a long period of relatively limited gold accumulation. The rate of formation of economic deposits increased again after this period, especially in the last 100 million years of the earth's history.

With the exception of the Witwatersrand deposits, Archean gold is found closely associated with the igneous rocks which constitute the "greenstone" belts of the ancient continental shields. Production from the Archean shields of Southern Africa, Canada and Australia has been 2 to 3 kg per square kilometre whereas, to date, the Archean of Brazil has been much less productive (figure 4).

Economic concentrations of gold in rocks of the Proterozoic age (570 MY to 2200 MY) mainly occur in sediments

4. B.W. Mackenzie and M.L. Bilodeau, Economics of Mineral Exploration in Australia: Guidelines for Corporate Planning and Government Policy, Australian Mineral Foundation, Private Bag 97, Glenside, South Australia, 5065, 1984.

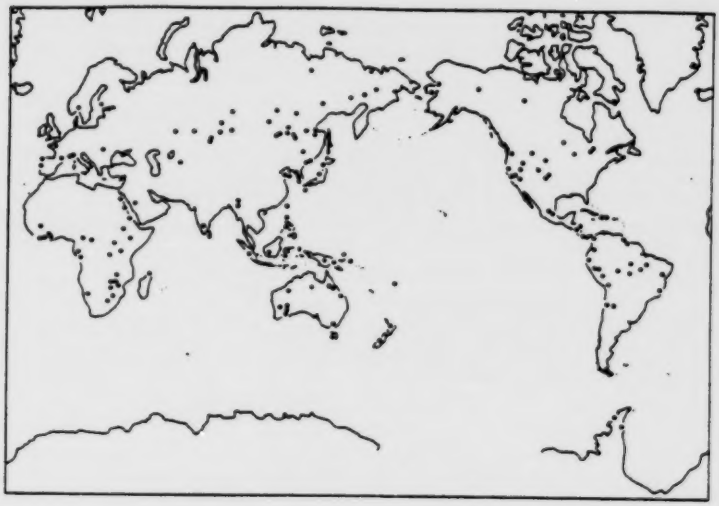

Figure 3. World - Gold Deposits

AREA		GOLD PRODUCTION		
TOTAL M km²	ARCHEAN M km²	TONNES	kg/km²	
8.3	2.57	1600	0.6	BRAZIL
7.9	1.2	2400	2.0	AUSTRALIA
9.97	2.2	6100	2.8	CANADA

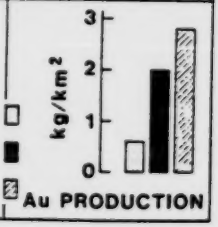

Figure 4. Gold Producing Regions

deposited in low-energy environments: e.g. Pilgrim's Rest in South Africa, Telfer in Western Australia, Morro Velho in Brazil and Homestake in the United States. These deposits form a distinct ore type which is not obviously associated with volcanism or other igneous activity. The Olympic Dam deposit in South Australia, besides being a large copper-uranium deposit, is a large, low-grade (0.6 g/t) accumulation of 1,200 tonnes of Proterozoic gold. We understand very little about the Proterozoic deposits. Why are they so different from the deposits of the Archean and younger geologic periods?

Gold deposits are a feature of the last 100 million years, associated with late-Mesozoic, Tertiary and recent volcanics and intrusives. A major gold resource of this type surrounds the entire Pacific Ocean and includes the gold-producing western states of the USA and the gold-rich porphyry copper deposits of the western Pacific.

A great deal of the world's gold has been produced from placer deposits; assuming that much of the gold mined by early civilizations came from placers, these deposits account for about a third of total world gold production. The largest remaining deposits of placer gold outside of the USSR probably occur in South America, where Alberto and Terrones[5] estimate resources of 2,500 tonnes.

The opportunity for new discoveries of gold are thus greatest in the following geological provinces:

- the Witswatersrand basin and any time-equivalent extensions or repetitions,
- the Archean of Canada, Australia, Brazil, Africa and Asia,
- the Pacific Oean rim - including western North America,
- certain unique environments in the Proterozoic.

Developments in the western USA, Australia, Brazil, and in countries bordering the Pacific and Asia deserve special mention. The USSR, Africa and Canada are outside the scope of this paper.

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5. J. Alberto, and L. Terrones, "Overview of the mineral resource potential of Latin America in relation to global tectonic and metallogenic controls", Global Tectonics and Metallogeny, vol. 2, nos. 3 and 4, 1984, pp. 213-256.

Western United States of America

The United States of America has produced about 11,600 tonnes of gold, mainly from the western states. Of this, 3,500 tonnes was placer gold and 1,400 tonnes by-product gold.[6,7,8] With a past production of 5,500 tonnes of lode gold, and lode gold reserves of 1,500 tonnes, the region is well endowed and still prospective. The known reserves occur on about 60 properties and another 80 properties are currently the subject of advanced evaluation. Production was 79 tonnes in 1985 and could rise to 140 tpy early in the 1990s.

In 1985, the exploration budgets of major mining companies totalled about U.S. $170 million, down perhaps U.S. $60 million from 1983, a large part of which was devoted to gold exploration. Most of the recent gold discoveries have been made in old mining districts often where earlier explorers missed fine gold. As a result of heap-leach technology and open pit mining, direct operating costs on some properties are less than U.S. $10 per tonne. Capital costs per annual ounce for 10 new producers listed by Hope[9] are equivalent to U.S. $374 per annual ounce. An independent study of 37 new and potential producers has suggested a similar figure of U.S. $437 per annual ounce.

Australia

Australia has produced 6,200 tonnes of gold - 1,700 tonnes from placers and 4,500 tonnes from lode deposits. The lode gold has come almost equally from the Archean of Western Australia (2,400 tonnes) and the Paleozoic (1,900 tonnes), with minor production from the Proterozoic (200 tonnes). Production during 1985 was 57 tonnes and during the second half of 1986 was at a rate of 74 tpy. Australia's gold production should rise to 100 tpy during 1988 and to 120 tonnes per annum by early in the 1990s if the present conditions of price and fiscal policy (no company tax) continue.

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6. S.M. Cargill, "United States gold resource profile", Scientific Communications, 9 May, 30 September, 1980, pp. 937-943.
7. G. Milling-Stanley and T. Green, Gold 1986, Consolidated Gold Fields, 1986.
8. Thomas and Boyle, Gold Availability - World: A Minerals Available Appraisal.
9. D. Hope, "World Gold Projects", Mining Magazine, September 1986, pp. 184-205.

Gold exploration has increased dramatically over the last five years. In Western Australia, where the emphasis is on exploration in the Archean, exploration expenditure increased from A $22 million in 1979/80 to A $111 million in 1984/85. During this period A $395 million was spent on exploration, resulting in 46 new gold operations which will produce 25 tpy, and 246 tonnes of gold were added to ore reserves at a discovery cost of A $50 per ounce.

The majority of these new discoveries resulted from drilling around old mines for which no new exploration technology, other than reverse-circulation drilling, was required. The success of this exploration has been mainly due to the high gold price and the advent of carbon-in-pulp and carbon-in-leach extraction technology which has made it economic to treat clay-rich, oxidized ores with saline water. There are, however, very extensive areas of deep soil, deep weathering and surficial cover and therefore great opportunity for geochemistry, geophysics and drilling to discover near-surface, concealed deposits. The first of these new discoveries are now being announced, e.g. in the Kambalda region. More recently, there has been increasing interest in exploration for deep ore beneath old mines and the most notable success to date is at the Lancefield mine near Laverton.

Exploration in central, northern and eastern Australia has resulted in nine new gold operations which will produce 15.5 tpy. The development of the large, low-grade Kidston deposit, now Australia's largest producer at 7 tpy, has highlighted the potential that now exists for economic production from large, low-grade (2 g/t) deposits associated with late-Paleozoic intrusions. Underground evaluation has commenced on the famous Bendigo goldfields which have a past production of 157 tonnes and where exploration has been dormant for 50 years.

The capital cost of increasing production in Western Australia between 1981 and 1986 is estimated to be A $600 million (i.e. A $750/annual ounce), but some producers with open cut ore have commenced production after an expenditure of as little as A $109/annual ounce.[10]

Brazil

Brazil's potential for significant new gold discoveries is considerable. This conclusion is reached when the following facts are considered:

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10. Ibid.

- Brazil has a long history of gold production, dating back to 155211 during which time the country has produced 1,750 tonnes of gold;

- seven of the ten large deposits known in Brazil have been found since 1976;

- Brazil has extensive areas (2.6 x 10^6km) of Archean, which is similar in area to Canada's (2.2 x 10^6km^2) and more than twice the area of the Archean in Australia (1.2 x 10^6km^2);

- Brazil has extensive areas of Proterozoic sediments and a surprising number of gold occurrences in these sediments;

- alluvial and shallow colluvial diggings are widespread;

- large areas are deeply weathered, often heavily forested, and in general, relatively unexplored;

- Brazil's current gold exploration boom is the first for over a century.

The paucity of "greenstone" belts on maps of Brazil's Archean in comparison with Australia (figure 5) reflects inadequate geologic mapping rather than absence of the volcanic rocks so closely associated with Archean gold deposits.

Investment in underground mining was revitalized by Anglo America Corp. do Brasil in the Nova Lima and Jacobina districts and gold production from these lode deposits, which was only 4 tpy between 1976 and 1982, rose to 7.5 tonnes in 1985.

Small-scale mining by 250,000-500,000 prospector-miners ("garimpeiros") has been an important feature of Brazilian production for many years, especially since 1971 (figure 6). Garimpo production in 1985 was about 55 tonnes. This is equivalent to only 3.5 to 7 ounces per man per year, but, as the minimum wage is only U.S. $60 per month, this activity is likely to continue. Although the garimpeiros are moving from the manual mining of placers and weathered rock to small-scale mechanized mining, their production is expected to fall to about 40 tpy by 1990, despite the financial incentive - assuming of course, that no more "Serra Peladas" are found in the dense, vast Amazon region.

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11. E.A. Schiller, "Gold in Brazil", Mining Magazine, October 1985, pp. 313-319.

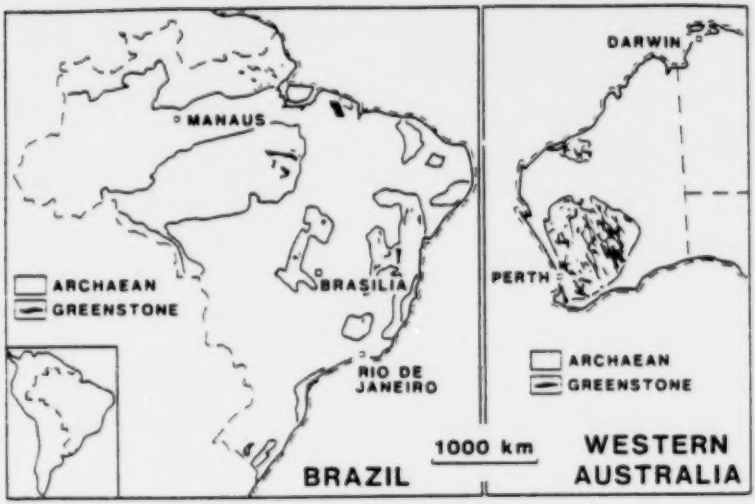

Figure 5. Brazil and Western Australia: Gold Producing Regions

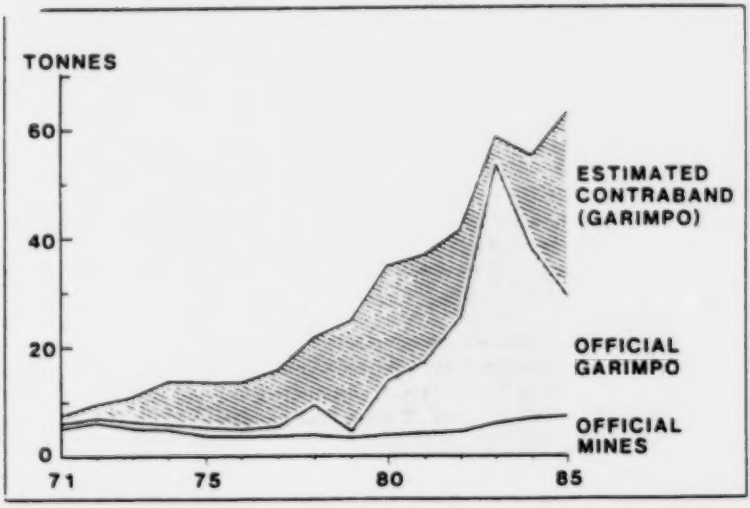

Figure 6. Brazilian Gold Production

Many companies are now exploring for gold in Brazil and already there has been sufficient success to lift lode production to 32 tonnes by 1990. Capital investment to bring in new mines with a capacity of 24.3 tpy is estimated at U.S. $640 million, i.e. $820/annual ounce.[12] Given the current exploration activity, the relatively unexplored nature of the country, and the government's encouragement of gold production, it would not be surprising if Brazil's production rose to about 75 tpy by 1990 and 100 tonnes soon after.

The future for more mechanized placer mining is uncertain, but Alberto and Terrones[13] estimate resources of 940 tonnes of placer gold in the Central Brazilian Precambrian Shield alone.

Pacific Ocean Rim (inc. Central America)

The discovery of the Hishikari gold deposit in Japan (120 tonnes) with its spectacular grades, the Lihir and Porgera deposits in Papua New Guinea (360 and 335 tonnes), the McLaughlin mine in California (100 tonnes), El Indio in Chile (50 tonnes) and Pueblo Viejo - Monte Negro (24 tonnes) in the Dominican Republic have served to reemphasize the prospectivity of areas of late-Mesozoic to recent igneous activity which rim the Pacific Ocean.

In 1985, production from the Pacific Ocean Rim, excluding USA and Canada, was 186 tonnes:[14] 86 tonnes from the western side (including Japan) and 100 tonnes from the equivalent geological terrain in Central and South America (table 1).

The main producing countries in the Western Pacific are the Phillipines (38.5 tonnes) and Papua New Guinea (33.2 tonnes) which account for 71.7 tonnes or 83 percent of the total production. Two thirds of this 1985 production, 46 tonnes, was a by-product from the mining of porphyry copper deposit; in fact, two of the largest gold producers outside of South Africa and USSR were the porphyry copper deposits of Bouganville (15.7 tonnes) and Ok Tedi (14 tonnes) in Papua New Guinea.

12. P.C.D. Burnell, Brazil in the World Gold Business, Presentation to Financial Times "World Gold in 1986" Conference, London, June 1986.
13. J. Alberto, and L. Terrones, "Overview of the mineral resource potential of Latin America in relation to global tectonic and metallogenic controls".
14. G. Milling-Stanley and T. Green, Gold 1986.

The potential for further lode gold discoveries in the countries bordering the Pacific is excellent, given that the area is so favourable for epithermal deposits. As these deposits show strong vertical zoning and grade distribution, major ore deposits can exist close to the surface but not be exposed. Much of the area is also remote primordial rain forest or high mountains and is therefore poorly explored. The physical environment and lack of infrastructure will be a handicap, however, at the development stage.

An indication of the potential of the Western Pacific can be gauged from the estimates of gold reserves in recent discoveries (table 2).

Table 2

ESTIMATED GOLD RESERVES IN RECENT DISCOVERIES

	Contained Gold (tonnes)
Porgera (PNG)	335[a]
Lihir (PNG)	360[b]
Misima (PNG)	70[b]
Martha Hill (Waihi, N.Z.)	85[c]
Gold Ridge (Solomons)	100[c]
Kelian (Indonesia)	90[c]
Hishikari (Japan)	120[c]
Total	1160

[a] from A.W. Fleming, et al., "The Porgera Gold Deposit", Papua New Guinea, Economy Geology, vol. 81, 1986, pp. 660-680.

[b] from D.S. Tyrwhitt, "Gold Production and Exploration Potential in the South-West Pacific", The Mining Review, Australian Mining Industrial Council, June 1986, pp. 15-19.

[c] from F. Reid, 1986 (personal communication).

All these recent discoveries are epithermal-type deposits and, assuming a 20-year life, have the potential to produce 50 tonnes of gold per annum.

About half the exploration effort in the Pacific region of South America is being devoted to Chile. Here, exploration has focused on mid- to late-Tertiary epithermal prospects with both bulk-tonnage and high-grade vein gold potential. More recently, gold prospects associated with

base metal districts, including porphyry copper districts, have received increased attention. Exploration activity is also increasing in Ecuador, Columbia and Costa Rica.15

Production from the Pacific Ocean rim should exceed 200 tonnes by the early 1990s and a reasonable expectation is about 230 tonnes. The full potential, however, of the regions bordering the Pacific, both in the Western Pacific and Central and South America, will only be realized if the region can maintain political stability and if governments encourage mining development through reasonable regulatory and taxation policies.

Asia and Africa (excluding South Africa)

The gold potential of China is considerable, considering its area and the occurrence of both Archean and young igneous terrains. There is, however, little solid data on which to base a judgment of the impact of exploration and development on world gold supply.

India is an enigma. It has only one major goldfield at Kolar, where production amounts to 790 tonnes, but is falling. One must question if exploration and mining is being encouraged by the government and is under competent management. Similar comments apply to Zimbabwe, Ghana and Zaire.

Exploration Potential at Operating Mines

With the gold price rising faster than costs, and scientific and technological expertise increasing, most of the present operating gold mines should be able to continue producing far beyond the life of their published reserves. Whether this happens will depend on the policies of both management and government. If cash surpluses are absorbed largely in dividends and taxes, and mine-area exploration is deprived of adequate finance, there will be insufficient discoveries to significantly extend mine life. If, however, mines are staffed with geoscientists who are encouraged to study the known ore deposits and their environments carefully, and to use the new exploration technologies, much new ore will be found. In this work there is considerable scope for contributions from scientists in government research organizations and the education sector.

15. J. Hunt, personal communication.

The best example of the benefits of careful mine-area documentation, good mine management and supportive government fiscal policy (i.e. no company taxation), is the case of Central Norseman Gold Corporation in Western Australia. Its history over 50 years is shown in figure 7. At no stage has this operation had published reserves of more than a few years' production, yet it has survived for half a century. During this time five new discoveries have been made, the last being one of the richest, certainly the most profitable, and the closest to the surface. The cost of exploration at this operation over the past 10 years has been A $11 million and the reward has been 650,000 ounces of additional gold at a discovery cost of only A $17 per ounce. The mine environment can be the most prospective of all, and ore found near existing mine facilities the most profitable of all.

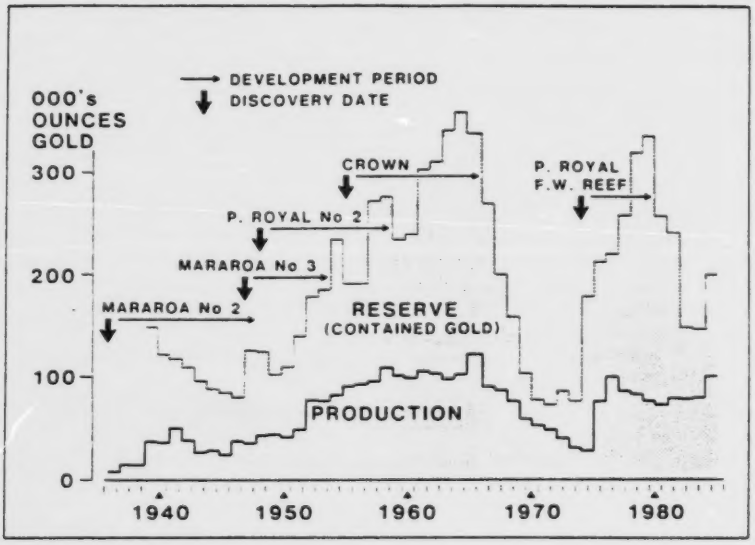

Figure 7. C.N.G.C. - Annual Production and Reserve

The Central Norseman experience can be repeated throughout the world wherever there are major ore deposits in complex geological settings. If this occurs, the impact will be great. But to bring this about successfully as an economic investment, a number of factors need to receive attention:

- mine management must encourage the continuous scientific study of both the orebodies being mined and the regional environments in which the ore deposits occur;

- highly motivated, well-trained geoscientists must be based at the mines, supported by adequate exploration funds;

- governments must provide a long-term, stable regulatory environment and supportive taxation policies.

Conclusions

A renaissance is occurring in the development of new strategies and new technologies applicable to gold exploration. Together with the present high price of gold, especially in countries which have devalued their currencies relative to the U.S. dollar, this has resulted in a substantial investment in gold exploration and the discovery of many new deposits.

Excellent potential for further discoveries exists in Australia, Brazil, the USA, and in the countries bordering the Pacific Ocean. Production from these areas, which was 385 tonnes in 1985, should exceed 500 tonnes by 1990. Only a fall in the price of gold or restrictive practices and repressive taxation by government can prevent this level of production from being obtained and perhaps increased even further.

There is no evidence that gold production will decline due to depletion through mining. On the contrary, new exploration technologies, new scientific exploration concepts, and new production methods are more than adequately compensating for such reduction in the natural endowment as has resulted from past production. Only if exploration is hampered by management or government policies, or if there is a major collapse in the price of gold (which seems unlikely), will we see any decline in either gold reserves or gold production. On the contrary, an increase in both is more likely in the next 10 to 20 years.

FACTORS AFFECTING THE LONG-TERM PROSPECTS OF SOUTH AFRICA'S GOLD PRODUCTION

Danie Krige

Introduction

The gold production potential of a country such as South Africa is dependent on a number of factors, most of which are outside the control of the producers themselves. The major factors are:

1. the gold grade/tonnage potential of existing mining areas and reefs, extensions and new areas;

2. the gold price in U.S. dollars, and in South Africa rand; this involves the $/R exchange rate and thus also the relative inflation rates in the USA and S.A.;

3. the uranium price and uranium by-product grades of the gold ores which determine uranium's indirect contribution to gold production (At the moment this is relatively insignificant and will not be considered.);

4. cost trends in S.A. (operating and capital) as linked to inflation trends, increasing depths of workings, productivity, wage levels as negotiated with labour unions, effects of strikes, etc.;

5. The volume and "cost" of the capital investment required for extensions to existing mines and for new mining propositions;

6. The availability and costs of other resources and facilities required for the exploitation of the gold ore potential, i.e. manpower, skills, equipment, capital, infrastructures, markets, etc. (These are linked to (iv) and (v) above).

This analysis will not attempt to address the above factors individually and in detail, but will concentrate mainly on

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The assistance provided by Mr. D. Kyle in assessing the potential of new areas and by Mr. P. Sewell with data collection, computer calculations and plotting is gratefully acknowledged. Mr. C. Suhr also assisted.

two aspects: ore potential and pay limits (cut-off grades). Ore potential is highlighted above under (i), and pay limits can combine the effects of items (ii) to (v) and indirectly also (vi).

Pay limits will be analyzed in relation to:

1. operating mines (operating pay limits),
2. extensions to existing areas and/or reefs (marginal flotation pay limits),
3. new mining areas (flotation pay limits).

All three pay limits will depend on trends in the gold price, working costs, and the relative escalation rates for these. Pay limits ii) and iii) also depend on the "cost" of investment capital required to exploit such extensions and new areas. These pay limits will be defined in more detail later.

In order to have a base for a model to predict the future, historical trends in these pay limits and in the inherent factors of prices and costs will be studied in broad outline only. The model will attempt, via various scenarios, to cater for a range of uncertainties in predicting the future.

Historical Gold Price Trends

When studying the annual gold prices per kg in U.S. dollars and S.A. rand currencies from 1920 to 1985, it is immediately evident that the U.S. and S.A. prices follow each other very closely for the period 1950-83, with significant departures for the periods before 1950 and after 1983. This suggests that the Purchasing Power Parity (PPP) theory held very well for the main period[1] but was affected by extraneous factors before 1950 (World War II and world depression?) and also during 1984-85 (international pressures on S.A. and its currency?). During the period 1950 to the early 1970s the gold price was pegged.

Figure 1 shows growth-curves fitted to the prices for the years 1920, 1950 and 1973-85, i.e. exclusive of the what I consider to be the abnormal periods in between. The curves have been forced through the 1950 position as

1. Krige, "Long-Term Domestic Metal Price Trends Under International Conditions of Differential Inflation Rates and Unstable Currency Exchange Rates", Journal S.A. Institute Mining and Metallurgy, September 1978.

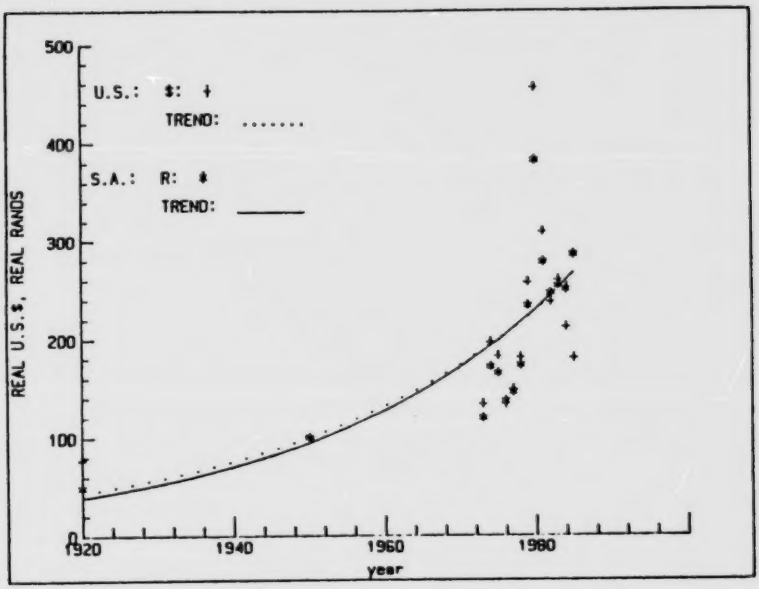

Figure 1. Real Gold Price Growth Curves Fitted to the Prices in 1920, 1950 (index) and 1973-85

the index year. The curves for the USA and S.A. are virtually coincidental. They show growth rates of 2.8 and 3.0 percent p.a. respectively.

Historical Working Cost Trends

Because mining depths and other conditions vary significantly between the five individual South African goldfields, costs per tonne milled for these fields were analyzed separately. The results (all in real terms) are shown on figure 2 for the period 1935-85. Working costs followed what I consider an artificial trend up to 1970, during the period when the gold price was pegged and the lower grade mines were struggling to survive. The industry was thus not in a position to increase wages adequately. Since 1970 this position has changed drastically, particularly in respect to unskilled (i.e. generally black) labour - wage increases for the latter for this period far exceeded the inflation rates.

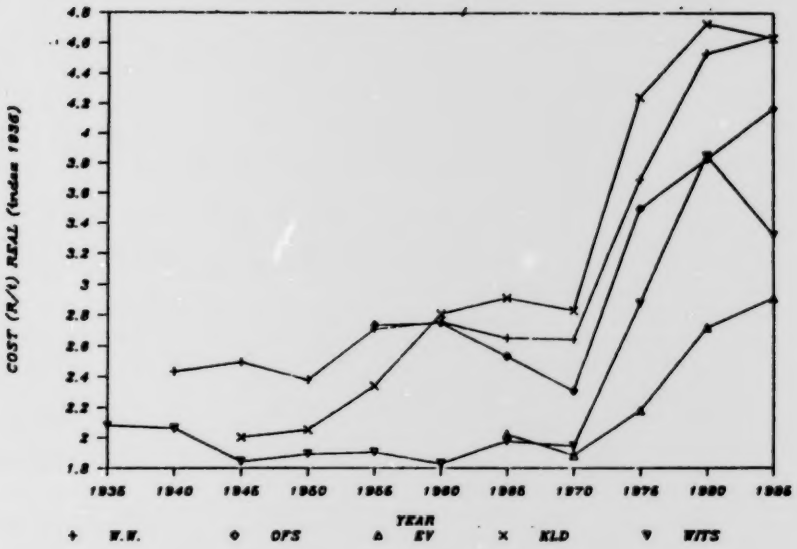

Figure 2. Working Costs in Real Terms for the Five South African Goldfields for 1935-85

The annual growth rates in costs since 1970 have, therefore, also been abnormal and cannot be accepted as a criterion for the future, except possibly for a further few years only until any remaining wage backlog has been wiped out. The industry has now reached the position of being able to compete with secondary industries for local black labour, hence the reduction in the reliance on foreign labour.

The present situation is that the black labour union is flexing its muscles, but faces, on the one hand, massive unemployment of unskilled workers in neighbouring countries and also, to a lesser extent, within South Africa. On the other hand, wages and working conditions for unskilled workers have improved very substantially in line with the accepted policy of equal pay for equal jobs regardless of race. Furthermore, the training of black workers for more skilled positions is an ongoing process and thus the motivation for major strikes on purely economic grounds is not strong. For political reasons, however, the industry can expect short illegal strikes from time to time; long legal

strikes are, in my opinion, not very likely. Sabotage of mines will always be possible on a limited scale, but has not been a problem to date.

In summary, therefore, I believe that future wage increases for unskilled and skilled workers will generally not be significantly out of line with inflation, and hence that working costs will not be affected much, if at all, by political and other non-technical factors.

An analysis of the trends on figure 2 shows that from 1945-70 have been from negative values to 1.4⅝ percent p.a. an average of 1 percent, and from 1970-85 growth rates were from 3.1-3.8 percent p.a. If the figures for 1945 (or 1950) and 1985 only are used, the growth rates range between 1.4 percent and 2.4 percent p.a. These levels appear reasonable if it is accepted that wages have already reached or are close to a realistic level. If the increases since 1970 continue at the same rate for a further three years, the long-term rates will rise only slightly to the range 1.6 to 2.5 percent p.a.

For the future, the critical figure will be the differential between the growth rates for working costs and gold price, as this will determine the future trend of pay limits. This differential appears to be in a range from say -0.5 to -1.5 percent p.a.

Historical Trends in Working Pay Limits

Figure 3 shows the trends in working pay limits for the five goldfields (expressed as recovery grades required to cover working costs) and these clearly also demonstrate the abnormalities for the period up to 1970 and since 1970. If only a starting year (1945 or 1950) and 1985 are used, the "growth" rates for pay limits are negative in the range -0.8 to -1.6 percent p.a., which is slightly in excess of the range of the differential between prices and costs as shown above.

It is suggested therefore that, to cover this aspect, two scenarios be accepted for the future: a "pessimistic" one with no differential and therefore a constant pay limit level, and an "optimistic" one with a differential of say -1 percent p.a., i.e. pay limits decreasing at a rate of 1 percent p.a.

A reasonable average working pay limit for mines at present in production appears to be a recovery grade of 3 g/t (early 1986). For the optimistic scenario of a 1-percent p.a. reduction in this limit, the recovery grade would reduce to 2.7 and 2.4 g/t in 10 and 20 years time respec-

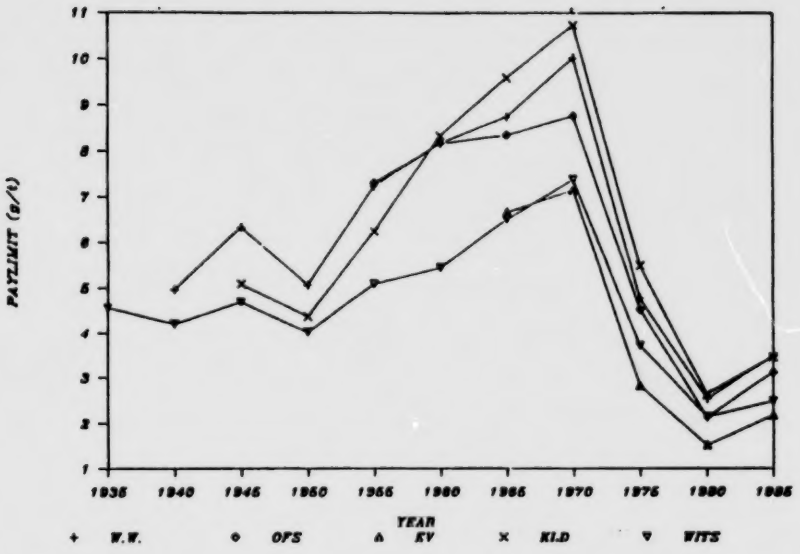

Figure 3. Recovery Pay Limits for the Five South African Goldfields for 1935-85

tively. A limit of 2.5 g/t is therefore accepted for the optimistic case.

A further major factor will be the general level of the pay limit as determined essentially by the rand price of gold. The 3 g/t level corresponds to a gold price of R 25,000 per kg ($400 per oz. at a $/R rate of 0.51) and average working costs of R 75 per ton. This agrees closely with the projection of the trend line on figure 1. The variations about the trend line are large, and the August 1986 price level was R 32,000 per kg. Instead of using an extrapolation of the trend line, a range of realistic "present" prices from say R 22,000 to R 30,000 per kg has been accepted and would correspond to a pay limit range from 2.5 to 3.4 g/t. With the superimposition of a possible price/cost differential of 1 percent p.a. the range is, therefore, taken at 2 to 3.4 g/t, i.e. from -33 percent to +13 percent relative to the early 1986 level of 3 g/t.

Historical Trend in the Flotation Pay Limit

The flotation pay limit for a new mine is defined as that recovery grade which, at estimated costs and prices, will ensure a minimum basic return or hurdle rate of 7 percent p.a. in real terms on the capital investment required.[2] Such a limit will naturally depend, inter alia, on physical factors peculiar to each property, such as depth of workings, mining conditions, etc.; these have changed drastically over the last 50 years.

Flotation pay limits were therefore calculated for a prewar new mine and a 1987 new deep level mine with the main parameters as set out in table 1. On these parameters, the flotation pay limits are 10.2 g/t for 1935 and 7.0 g/t for 1986. The 1986 flotation pay limit can, however, vary significantly with a number of factors of which the following are more important:

- as discussed above, the "present" gold price taken over the range R 22,000 to R 30,000 per kg;

- price/working cost differential: as shown above this could be a favourable 1 percent p.a.;

- taxation levels: At present there is a discriminatory 25 percent tax surcharge on gold mines, arising from budget requirements during a recessionary period. An optimistic scenario should cater for the lifting or at least a reduction of this surcharge, i.e. a reduction of the "A" factor from 75 towards 60. Other tax considerations such as a change to a flat rate and/or changes in the handling of major mergers could also make some minor positive or negative contributions;

- variations in mining conditions for individual projects and consequential variations in the above parameters.

The 1986 flotation pay limit was therefore recalculated to determine the effects of combinations of changes in the above factors. The conclusion reached is that the range of possible flotation pay limits can be covered by a "pessimistic" level of 10.2 g/t and an "optimistic" level of 5.8 g/t.

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2. D.G. Krige, "Threshold Rates of Return on New Mining Projects as indicated by Market Investment Results", J.S. Afr. Inst. Min. Metall; vol. 80, October 1980, pp. 370-377.

Table 1 Parameters for Calculation of Flotation Pay Limits

		1935	1986 (Aug.)
Average depth (m)		2,000	3,000-3,500
Preproduction period (years)		4	7
Capital expenditures up to full production (in millions)		R 9.5	R 1,500
Full milling rate - mtpy		1.3	3
Working costs per tonne		R 2.54	R 100
Gold price per kg		R 435	R 32,000
Life from inception (years)		30	37
Taxation and lease :	A factor	55 and 10	75 and 15
	B factor	9.09 and 6	8 and 8
Capital allowances :	tax	nil	10% p.a.
	lease	5% p.a.	6% p.a.
Capital redemption for tax		5 yrs.	immediate

Escalation/inflation differentials (% p.a.):

	Year	1935	1986
Gold price:	1-15	-2	0 p.a.
	15	0	0 p.a.
Working costs:	1	0	5
	2	0	3
	3	0	0
Capital expenditure:	1	3	10
	2	1	8
	3	0	5
	4	0	0

Note: for a 0 percent differential, the future gold price in rand terms, for example, is assumed to increase in line with the future South African inflation rates.

[a] at full production

Marginal Flotation Pay Limits

The August 1986 flotation pay limit of 7.0 g/t has been recalculated for the same parameters but with the added assumption that an existing producer could implement such a project on its existing lease area or on adjacent ground to be incorporated. The project would then operate on the "marginal" basis of offsetting all capital expenditure immediately against profits currently being earned on existing operations. This has a very drastic effect and, at a 7-percent p.a. hurdle rate, the flotation pay limit reduces to 4.0 g/t. If the hurdle rate is reduced to say 5 percent p.a. (real) to compensate for the lower risk resulting from the fact that the project is now part of an existing operation (for which a hurdle rate as low as 3 percent p.a. could be adequate,[3] the limit reduces further to 3.8 g/t.

For extensions to existing mines and for virgin areas and/or reefs in such mines where substantial capital investments are required, and after taking account of the accepted range of gold prices, tax levels and price/cost differentials, a marginal flotation pay limit range of 3.3 to 5.8 g/t is therefore accepted.

Trends of Recovery Grade versus Pay Limit

The effect of changes in the pay limit on the recovery grade depends on:

- the variability of the grades of ore units, i.e. ore blocks of a practical size for selective mining of the payable units only;
- the percentage of the ore being mined at the current pay limit;
- any change in the overall grade of the ore being developed.

The lognormal distribution can be accepted as a suitable statistical model for the distribution of the grades of ore blocks in a gold mine.[4] If the logarithmic variance of the grades of the ore units, is assumed to be in the range of

3. Ibid.
4. D.G. Krige, Lognormal De-Wijsian Geostatistics for Ore Evaluation, Johannesburg, S. Afr. Inst. of Min. and Metall, Monograph Series, vol. 1, 2nd edition, 1981.

0.05 to 0.3, the effect on the recovery grade of joint changes over time of the pay limit and developed ore grade can be calculated theoretically for a range of say 80 to 95 percent. This was done for a combination of 10 mines selected from the Evander, West Wits and Klerksdorp fields for which the statistics in table 2 were available:

Table 2

RESULTS FOR A COMBINATION OF 10 MINES

Years	Recovery Pay Limit	Development Grade Previous 3 yrs.	Recovery Grade
1971/72	7.81 g/t	15.34 g/t	13.66 g/t
1983/84	3.74 g/t	10.05 g/t	7.95 g/t
Change	-52.1%	-34.5%	-41.8%

The "development" grades can be accepted as closely agreeing with the grades which would have been attained without any selective mining but before allowing for gold losses, dilution and sampling biases.

Application of the theoretical lognormal model[5] over the ranges of parameters mentioned and for pay limit and development grade reductions of 52.1 and 34.5 percent respectively gave corresponding reductions in recovery grade between 36 and 42 percent, as compared with the actual reduction of 41.8 percent. This model, therefore, appears suitable for forecasting future grade changes for various scenarios.

Overall Scenarios

A critical factor not yet covered is that of the likely overall grades and ore potentials of areas still to be developed in existing mines, extensions and in new areas. This warrants an in-depth study beyond the scope of this paper, but would in any case still involve personal judgment to a very major extent. For the purpose of this analysis the following has been accepted:

5. Ibid.

i Existing mines: allowing for the fact that the general levels of grade for ore being developed has already dropped very substantially, no allowance will be made for any further changes in this level.

ii Extensions: these would also cover lower grade reefs not yet or only partly being exploited and hence the grade level is accepted at a level significantly lower than present grades, i.e. at say 4.5 g/t. The volume of such extensions is very uncertain. It has been accepted as the equivalent of four large mines milling say 10 mtpy. for 20 years, i.e. a total of 900 tonnes of gold. The grades for individual areas could, however, be spread either side of 4.5 g/t, and this variation has been defined by a logarithmic variance of 0.1. The range of marginal flotation limits when applied to this potential, gives a range of additional gold production from 230 to 790 tonnes.

iii New areas: Discussions with geologists involved in the extensive exploration efforts ongoing at present within the Witwatersrand Basin suggest that the potential is very significant. An optimistic assessment indicates a potential of as many as 15 new mines (3 tpy, 30-year life for each) heavily weighted to areas close to and between the four newer goldfields. The average recovery grade to date for these four fields is 10.6 g/t with a logarithmic variance between mines of 0.15.

The higher grades areas are already mined out in existing mines (e.g. the rich areas in the Free State Geduld and many other mines); this accounts for the much lower present average recovery grade of 6 g/t. Also some lower grade virgin areas have not yet been opened up due to the higher flotation pay limits prevailing in the past.

The average grade for these 15 new mines should therefore be somewhere between 6 and 10.6 g/t. An average of 9 g/t would correspond to 10 mines at an average of 10.5 g/t and five mines at an average of 6 g/t. A lognormal model with a variability of 0.15 (logarithmic) between the 15 mines will then lead to a grade range for individual mines between about 4 g/t and 18 g/t. For the range of flotation pay limits indicated above (5.8 to 10.2 g/t), the corresponding range of new mines will be from four mines at an average of 13.3 g/t, to 12 mines at an average of 9.9 g/t.

The scenarios for the other factors already discussed are as follows:

Working pay limits:	2 to 3.4 g/t.
Marginal flotation pay limits:	3.3 to 5.8 g/t.
Flotation pay limits:	5.8 to 10.2 g/t.

Future Gold Production from Existing Producers

Based on personal judgement applied to each existing producer under early 1986 conditions, a profile of future gold production was estimated. This basic profile was adjusted to cater for a scenario of the pay limit ranging from 2 to 3.4 g/t (i.e. from -33 percent to +13 percent relative to the basic case). The following would then apply (logarithmic variance of 0.2 assumed):

Base case: mean 5.5 g/t, pay limit 3 g/t, recovery 5.95 g/t.

Change in recovery grade: from -6.2 percent to +4.0 percent

Change in life: from +12 percent to -8 percent

Change in total gold produced: from +5.1 percent to -4.3 percent

The production profiles (pessimistic and optimistic) are reflected by the lower set of two curves on figure 4.

Production from Extensions and New Areas

The additional gold production of between 230 and 790 tonnes from extensions will result mainly from longer lives of existing producers and will be evident only from about 1995 onwards.

New mines could come into production as follows:

Conservative case:
1 mine at 40 tpy for each of the following year spans from 1995 to 2024; from 1997 to 2026; from 1999 to 2028; and from 2001 to 2030.

Optimistic case: 30 tpy in 1995, increasing to 360 tpy by 2006, and decreasing again from 360 to 30 tpy between 2024 and 2035.

Forecast of Total Gold Production

If this additional gold production is now added to that of existing producers, the higher set of two curves shown on figure 4 then represents the pessimistic and optimistic profiles of total future S.A. gold production. Based on the assumptions made, it is evident that, whatever the scenario, South Africa's gold mining industry has a great potential and will continue to make a very substantial contribution to the future world supply of gold.

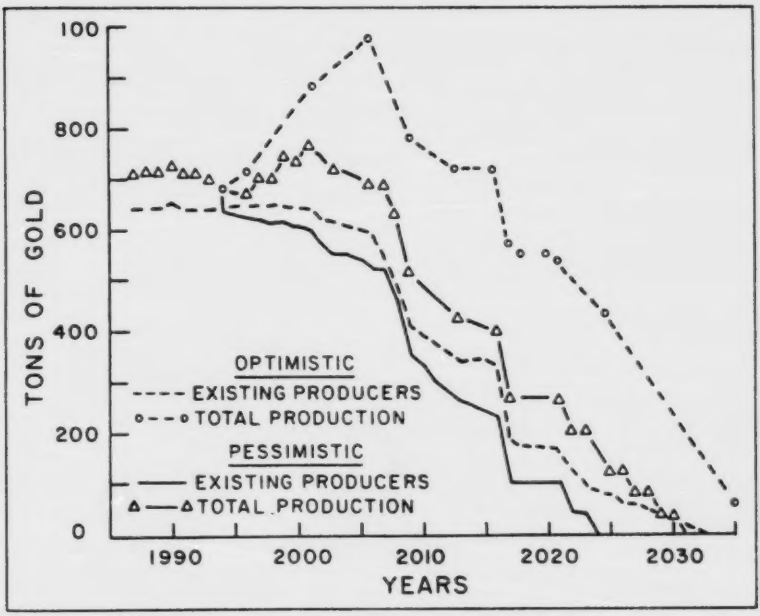

Figure 4. Forecast of Future S.A. Gold Production Under Various Scenarios

LONG-TERM BREAK-EVEN PRICE FOR CANADIAN GOLD SUPPLY

Donald Cranstone
Brian Mackenzie
Michael Doggett

Setting

The relevant gold price timeframe for long-term government policy formulation and corporate planning, viewed from the start of the gold supply process, extends far out in the future. Under normal circumstances, it may take eight years to find and delineate an economic gold deposit.[1] Then, another three years typically would be required for feasibility study work and development of the deposit to production. The resulting mine would produce and sell gold over its operating life of, for example, 12 years. This long-term planning timeframe is depicted in figure 1 in relation to historical gold prices expressed in constant 1985 Canadian dollars.

Thus, for long-term policy and planning, we don't really care what the price of gold will be in 1988, 1990, or 1995. The relevant gold prices are those which will prevail when the economic gold deposits presently awaiting discovery are in a position to produce and sell gold, most likely from the late 1990s to the turn of the century and beyond.

Can analysis of the historical gold price fluctuations and trends portrayed in figure 1 be used to predict the price of gold in a meaningful way this far out in the future? Not really. The track record of gold market experts in this respect is not good and, besides, the future timeframe considered is almost always too short. For policy and planning purposes, all we can do is:

- strive as hard as possible to remove the temporary influences of current market events from our thinking about future prices;

1. The exploration period is a function of the expenditures required per economic discovery and the annual exploration budget rate. Based on a $5-million budget rate, data subsequently presented for gold exploration in Canada suggest that this period may be somewhat shorter, averaging about five years.

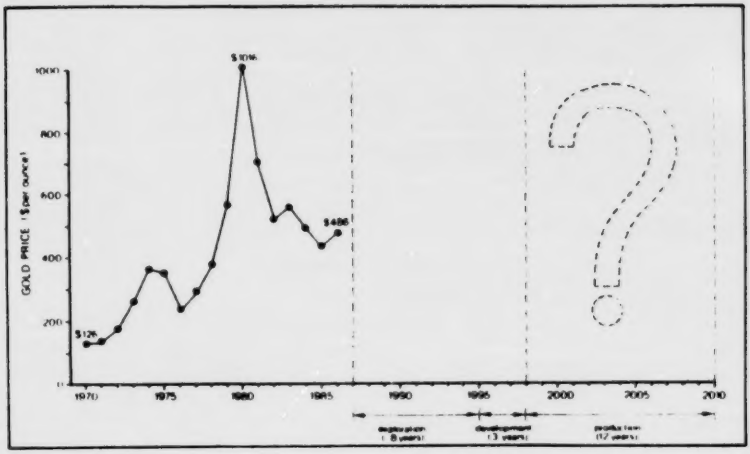

Figure 1. Relevant Gold Price Timeframe for Long-Term Planning

- base our appraisals on a wide range of future price possibilities, hoping we have bounded actual future prices;

- carry out our evaluations as much as possible on the basis of relative cost estimates, independent of future gold price projections.

The Question of a Long-Term Break-Even Gold Price

Approximately $800 million per year is currently (1987) being invested in gold exploration throughout Canada. Presumably, this money is being expended in anticipation of a suitably rewarding return on investment. However, as illustrated in figure 1, the future gold price - the most important determinant of that return - is extremely difficult, if not impossible, to predict.

Therefore, it is useful to address a related question - what minimum acceptable, or break-even, price of gold would be required in the long term to economically justify the extraordinarily high level of investment currently being placed in gold exploration. The reasoning behind making this type of assessment is that it should be somewhat easier to provide a meaningful judgment concerning which side of

the break-even "fence" the uncertain future gold price will be on than to make a more specific price prediction.

Evaluation Procedure

The long-term break-even price for Canadian gold supply is appraised by analyzing the cost structure of the gold mining sector. There are three relevant cost components:

- production costs for operating gold mines,
- development costs for new gold projects,
- exploration costs for discovery and delineation of economic gold deposits.

With respect to the development and exploration costs, timing differences between the years in which expenditures are incurred, and the years when the associated gold content is recovered and sold, must be taken into account. An 8-percent minimum required rate of return on investment is generally used here for this purpose. The 8-percent rate is our best estimate of the cost of capital for gold exploration and development funds.[2]

All money values (unless otherwise specified) are expressed in constant 1985 Canadian dollars.[3] The long-term break-even price is assessed on a potential value, before-tax basis.[4]

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2. The weighted average cost of capital in constant money terms comprises the costs of individual sources of funds. Sources of funds may be simply grouped into two types - debt and equity. When one considers inflation and taxation effects, debt capital represents a low cost source of funds, with after-tax constant money costs normally in the range of 1 to 3 percent. The cost of equity funds may vary from 6 to 15 percent. The financial structure of a mining company - basically how much debt and how much equity it utilizes - is applied to cost estimates for the individual sources to assess the weighted average cost of capital. The 8-percent cost of capital assumed for study purposes has been selected on this basis.
3. The Gross National Expenditure Implicit Price Index is used to convert historical data to 1985 Canadian dollar equivalents.
4. We do not consider the effects of mining taxation on gold exploration, development, and production costs. Thus, the sharing of these costs between industry and

Summation of the three time- and inflation-adjusted cost components, expressed in dollars per ounce of gold produced, will give the sought after long-term break-even gold price requirement.

Gold Production Costs

The distribution of costs for currently operating gold mines is pertinent to long-term planning because it indicates the possible production costs of future gold discoveries.

For each operating gold mine, cash production costs are defined as mining, milling, and overhead costs, less any by-product credits.[5] Annual production costs are divided by annual ounces of gold recovered to determine the production cost per ounce. A cumulative production cost distribution for all mines surveyed is constructed proceeding in order from the lowest cost to the highest cost producer. This distribution is represented by the following statistics:

- lower-decile cost: 10 percent of the ounces produced are recovered at a cost lower than this value;
- lower-quartile cost: 25 percent of the ounces produced are recovered at a cost lower than this value;
- median cost: 50 percent of the ounces produced are recovered at a cost lower than this value, the other 50 percent incurring a higher cost;
- mean cost: average production cost for all ounces recovered;
- upper-quartile cost: 75 percent of the ounces produced are recovered at a cost lower than this value;
- upper-decile cost: 90 percent of the ounces produced are recovered at a cost lower than this value.

The cumulative production cost distribution for Canadian gold mines operating in 1985 is presented in figure 2. Key statistics for producing gold mines in 1980 and 1985, expressed in both current and constant 1985 Canadian dol-

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government is not evaluated. The potential value level of assessment carried out here provides a more basic insight into the cost structure of gold mining, from the viewpoint of Canadian society.

5. Silver represents a significant by-product for several of the gold deposits included in the study.

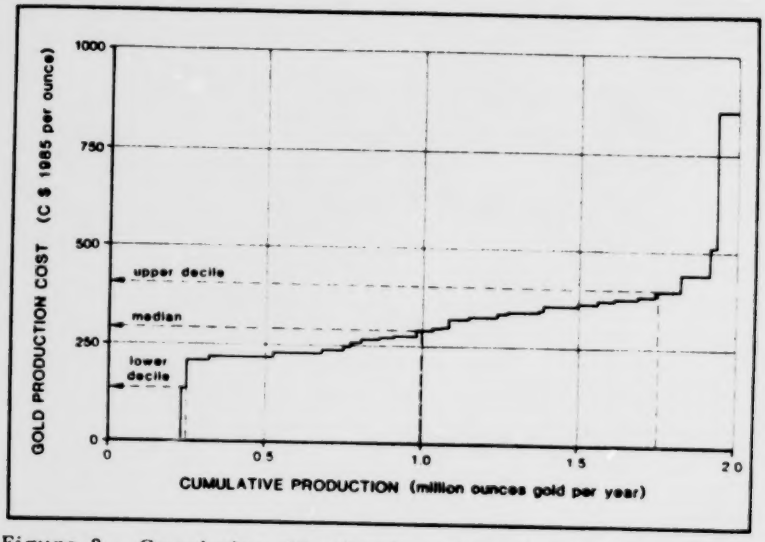

Figure 2. Cumulative Distribution of 1985 Gold Production Costs in Canada

lars, are summarized in table 1.[6] A high degree of production cost variability is evident among these mines.

Nominal current dollar production costs, shown in table 1, have increased from 1980 to 1985 for the lower-cost operators and decreased marginally for the higher-cost producers. The nominal median and mean costs increased by 28 percent and by 22 percent respectively. Once gold mining costs have been standardized in constant 1985 Canadian dollars, the real cost of producing gold in Canada is shown to have generally decreased over the 1980-85 period. The effect of the sharp decline in gold prices in 1980-85 (see figure 1) on the upper-decile and upper-quar-

6. The coverage for 1980 includes 20 mines which produced 1.04 million ounces of gold, accounting for 99 percent of Canadian lode gold production. In 1985, 30 mines which produced 1.94 million ounces of gold are included, representing 86 percent of lode gold production in Canada. The relatively low coverage in 1985 is mainly attributable to the exclusion from the assessment of development ore from start up of the three Hemlo mines, and the associated costs and gold content.

Table 1

GOLD PRODUCTION COSTS IN CANADA
(per ounce)

Key Statistic	Current $		Constant 1985 $	
	1980	1985	1980	1985
Lower-Decile	88	138	123	138
Lower-Quartile	159	225	222	225
Median	225	289	312	289
Mean	253	301	351	301
Upper-Quartile	361	361	501	361
Upper-Decile	432	403	601	403

tile costs which represent the high-cost producers is profound. The high-cost producers in 1980 have either been able to reduce their costs by raising cut-off grades and average grades mined and/or by technology improvement in order to remain viable, or else they have gone out of business. Otherwise, the mean and median costs declined somewhat, the lower-quartile cost remained essentially unchanged, while the lower-decile cost increased.

Selecting from the results presented in table 1, the following 1985 production cost statistics are used in appraising the long-term break-even price for Canadian gold supply:

Lower-decile cost - $138 per ounce;
Median cost - $289 per ounce;
Upper-decile cost - $403 per ounce.

Gold Development Costs

The cost of developing capacity to produce gold is estimated here on the basis of actual pre-production capital expenditure data and feasibility study estimates for 54 new Canadian gold projects which announced plans to proceed with development during the period 1980-86. The annual capacity associated with these new developments totals approximately 3.5 million ounces of recoverable gold.

For each potential new gold mine surveyed, time distributions are estimated for development capital costs[7] and ounces of gold recovered, as illustrated in figure 3. The 8-percent minimum return requirement is applied to equate the two distributions. This procedure allows us to work out the time-adjusted development cost per ounce of gold recovered for each project surveyed.

The cumulative development cost distribution constructed from the results obtained for the 54 projects surveyed is shown in figure 4.[8] Key statistics from this distribution are summarized in table 2. A high degree of variability in unit capital costs among new gold mining projects is apparent from the results presented.

Table 2

GOLD DEVELOPMENT COSTS IN CANADA
($ per ounce)

Key Statistic	Gold Development Cost
Lower-Decile	51
Lower-Quartile	76
Median	87
Mean	122
Upper-Quartile	134
Upper-Decile	184

7. Development capital costs include all expenditures made during the pre-production period as well as any capital expenditures required during a mine's operating life for expansion, underground development, modification of processing facilities, etc.
8. Development costs are a function of mine capacity. Thus, the costs for each gold mining project are weighted by mine capacity measured by the estimated annual ounces of gold recoverable. This is consistent with the approach used for the analysis of gold mine production costs.

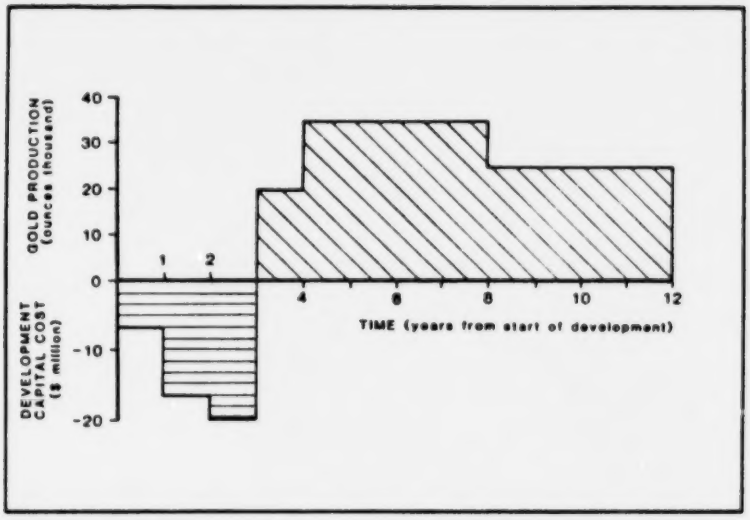

Figure 3. Time Distributions of Development Capital Cost and Gold Production for a New Gold Mining Project

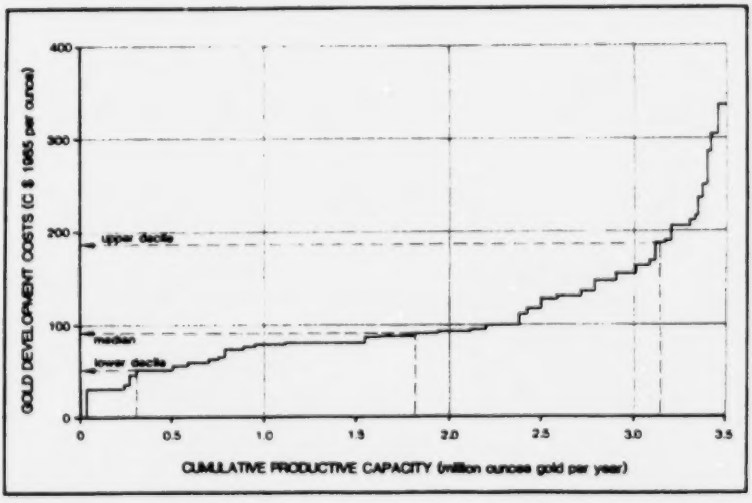

Figure 4. Cumulative Distribution of Gold Development Costs in Canada

The following development cost statistics (derived from figure 4 and table 2) are added into our long-term break-even price assessment:

Lower-decile cost - $51 per ounce;
Median cost - $87 per ounce;
Upper-decile cost - $184 per ounce.

Gold Exploration Costs

How much does it cost on average to discover and delineate an ounce of gold in an economic deposit? This third component of the long-term break-even price of gold is the most difficult to assess.

Background

A starting point in an attempt to answer this question is data assembled in a paper by Schreiber and Emerson, presented at the 1984 annual meeting of the Prospectors and Developers Association.[9] The authors made the following estimates for gold exploration in Canada during the 1961-83 period:

- total gold exploration expenditures of $1,825 million, converted to constant 1985 Canadian dollars;
- 20 possible economic deposits discovered as a result of those expenditures;
- 27.3 million ounces of recoverable gold contained in the 20 discoveries.

The Schreiber and Emerson estimates indicate an undiscounted exploration cost of about $67 per ounce of gold recovered. Applying an 8-percent discount rate to allow for the lag between the expenditure of exploration funds and

9. H.W. Schreiber and M.E. Emerson, "Discovery Costs of and Potential Cash Generation from North American Gold Deposits", paper presented at annual meeting of the Prospectors and Developers Association, Toronto, March 1984, 38 pp. A condensed version of this paper was subsequently published as "North American Hard-rock Gold Deposits: an Analysis of Discovery Costs and Cash Flow", Engineering and Mining Journal, October 1984, pp. 50-57.

the recovery of gold, this is equivalent to a time-adjusted discovery cost of $356 per ounce.[10]

There are several concerns about the Schreiber and Emerson data base:

- the exploration expenditures appear high in relation to total metallic mineral exploration expenditures incurred in Canada during the period;
- the inclusion and exclusion of several deposits from the discovery list is questionable;
- the estimated gold content for these discoveries is necessarily incomplete.[11]

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10. Determination of this time-adjusted value follows the same evaluation procedure and is based on the same assumptions that are used later in this section.

11. The starting point for the Schreiber and Emerson estimate of gold exploration expenditures was Statistics Canada data on metallic mineral exploration expenditures. Opinions were then surveyed concerning the percentage of metallic mineral exploration which was directed to gold deposits. Exploration expenditure data presented in the paper were grouped into time intervals. The following percentages of metallic mineral exploration attributable to gold are indicated:

1961-65	9.5%
1966-70	13.5%
1971-75	20.7%
1976-80	31.0%
1981-83	46.8%

The opinions surveyed were applied by Schreiber and Emerson to derive their gold exploration expenditure series.

There is nothing wrong with this procedure. It is an expedient way of arriving at an order-of-magnitude appraisal. As Schreiber and Emerson point out, however, the estimates are uncertain. Also, the percentages attributable to gold appear high, particularly for the 1961-75 period when gold exploration was modest relative to the search for copper, zinc, nickel, uranium, and other metallic mineral deposits.

The need for a more explicit economic analysis to define the discovery list is highlighted by the discussion which followed the Schreiber and Emerson paper. See letter to the editor by D.A. Cranstone, The Northern Miner, 18 October 1984, and reply by

An Independent Appraisal

For these and other reasons, an independent appraisal of gold exploration costs was undertaken. While the data assembled are approximate, they are considered good enough to provide a meaningful order-of-magnitude assessment of discovery costs in Canada.

The appraisal documents Canadian gold exploration experience during the period 1946-85. In order to illustrate time trends, this 40-year period is subdivided into three decades and two five-year intervals: 1946-55, 1956-65, 1966-75, 1976-80, and 1981-85. The following five regions are considered within Canada:

- Appalachian region, comprising Newfoundland, Nova Scotia, and New Brunswick;
- Quebec;
- Ontario;
- Western Shield region, including Manitoba, Saskatchewan, and the Northwest Territories;
- Cordilleran region, comprising British Columbia, and the Yukon Territory.

Methodology

As portrayed in figure 5, the evaluation procedure assesses time distributions for the exploration expenditures required on average to find and delineate an economic gold deposit and for the average ounces of gold recoverable from an economic discovery. A three-year period is assumed for feasibility studies and mine development. The 8-percent minimum required return on investment is applied to equate the two distributions, enabling an appraisal to be made of the time-adjusted exploration cost per ounce of gold. The effects of profitability thresholds of 5, 10 and 15 percent are also examined.

In essence, the methodology follows these steps:

1. Total gold exploration expenditures are estimated for the time intervals and regions of interest.

H.W. Schreiber, The Northern Miner, 29 November 1984; also "The Gold Debate", exchange of letters to the editor by D.A. Cranstone, H.W. Schreiber and M.E. Emerson, Engineering and Mining Journal, February 1985, pp. 50-51.

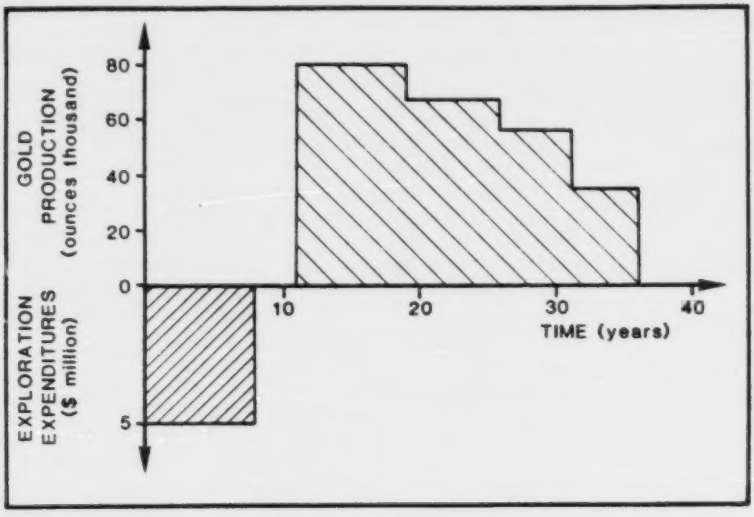

Figure 5. Time Distributions of Exploration Expenditures and Gold Production for the Discovery of an Economic Gold Deposit

2. Significant deposits discovered as the result of these expenditures are classified by discovery date and listed for evaluation.

3. Development and production phase estimates for each of these possible economic discoveries are evaluated on the basis of current outlook conditions.

4. Those discoveries which on evaluation satisfy the minimum acceptable profitability condition are considered to be economic deposits.[12]

5. The time distributions of ounces of gold produced from all economic deposits are averaged (figure 5).

6. Total exploration expenditures, which cannot in general be directly linked to the economic discoveries, are

12. The minimum acceptable profitability condition is imposed to allow for the cost of capital for gold exploration and development funds. While no explicit minimum acceptable size condition has been imposed, the intention is to include all known deposits of at least 150,000 tonnes which offer medium-term potential for development.

prorated across all economic deposits evaluated. The average exploration expenditure required to find and delineate an economic deposit is then divided by an assumed most-efficient annual exploration budget rate to evaluate the average exploration time which would be needed to make an economic discovery (figure 5). A $5-million annual exploration budget has been chosen for this purpose.[13] Assessments are also carried out for annual exploration budgets of $2.5 million and $10 million.

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13. The assumption of a $5-million most-efficient annual exploration budget is a subjective judgment based on discussions with exploration personnel and the opportunity to observe both successful and unsuccessful exploration at work. Opinions on this subject, of course, vary. While the $5-million figure may be criticized, there is little doubt that the most efficient exploration budget lies within the range of $2 million to $8 million per year. Results from a study of metallic mineral discoveries in Canada as a function of exploration budget size for the 1958-73 period, converted below to 1985 Canadian dollars, support this view.

Annual Exploration Budget	Percentage of Exploration Expenditures	Percentage of Economic Discoveries
$8 million	44	15
$4-8 million	14	35
$2-4 million	13	40
$2 million	29	10

See P.A. Bailly, "Changing Rates of Success in Metallic Exploration", paper presented at Geological Association of Canada annual meeting, Vancouver, April 1977.

If the annual budget is too small, the exploration organization will be unable to mount a modern, efficient, and competitive program. At the other extreme, a hazard arises as companies with larger budgets typically develop organizations where procedures become formalized and bureaucratic styles are permitted to develop. More discussion and sensitivity analysis illustrations on this issue may be found in B.W. Mackenzie and R. Woodall, "Economic Productivity of Base Metal Exploration in Australia and Canada", in World Mineral Exploration: Trends and Economic Issues, D. Sawicki ed., Resources for the Future, Washington, forthcoming.

7. The minimum required return on investment is applied to equate the time distribution of ounces of gold recovered with the time distribution of exploration expenditures per economic deposit. Consequently, the average exploration expenditure required to discover and delineate an ounce of gold in an economic deposit is assessed.

Gold Exploration Expenditures

Gold exploration expenditure estimates are based on data collected by Statistics Canada from exploration and mining companies.

During the 1946-74 interval, exploration expenditures were recorded, through the use of Statistics Canada questionnaires, according to the type of company that made the expenditures. For example, all exploration by gold mining companies was classified as gold exploration. Other companies were considered not to have explored for gold. While this was not strictly the case, we assume that exploration by gold mining companies for other metals was offset by exploration expenditures of other companies searching for gold. Following this reasoning, the figures compiled by Statistics Canada for 1946-74 should provide an approximation of gold exploration activity during the interval 1946-74.

From 1975, the Statistics Canada questionnaire sent to exploration and mining companies asks for breakdowns of exploration expenditures by commodity and province. An estimate of total gold expenditures in each province is obtained when individual company expenditures for gold are totalled. This is done for the years 1975, 1977, 1979, 1981, 1983, and 1984. The estimated value for 1985 is a preliminary Canada-wide figure which is disaggregated using 1984 provincial expenditure breakdowns. The years for which disaggregated data are missing during the 1975-85 interval are estimated by interpolating between the values for adjacent years.

Exploration expenditure estimates during the 1975-85 period include both outside or general exploration and on-property exploration. Each of these categories comprises four components: physical, land, administrative, and head office costs. For example, in 1983, the outside exploration category accounted for 85 percent of the total, while on-property exploration was responsible for the remaining 15 percent. Physical exploration activity accounted for approximately 81 percent of total expenditures while land,

administrative, and head office costs made up the other 19 percent. It should be noted that silver exploration expenditures are deducted from precious metal expenditure totals to obtain our estimates of exploration expenditures for gold.

The resulting gold exploration expenditures by region and by year in current dollars and in constant 1985 dollars are given in appendix I. Current dollar statistics (table 20) are converted to constant 1985 dollars (table 21) using the Gross National Expenditure Implicit Price Index.

These gold exploration expenditure estimates are summarized in table 3. Of the total gold exploration expenditure of approximately $2.0 billion, 32 percent was invested in Quebec, and 31 percent in Ontario. About 72 percent of the total was expended in the last decade of the 40-year study period, including 56 percent during the past five years. This indicates the exponential growth in Canadian gold exploration in recent years.

Possible Economic Discoveries for Evaluation

A total of 221 gold deposits discovered during the 1946-85 period were initially examined.[14] Of this total, 87 deposits were excluded from our evaluation for various reasons, e.g. too small, too low grade, or insufficient information to evaluate. Deposits which we have not evaluated are listed at the end of appendix II, the reason for rejection being cited in each case.

The remaining 134 gold deposits which could possibly satisfy the minimum acceptable return condition for an economic deposit are selected for evaluation. These deposits are listed in alphabetical order by region in appendix II, the discovery date being specified in each case. The discovery date is defined here as the point in time when positive indications of mineralization and minable widths are encountered, usually by drilling.

14. For the 1946-77 period, this deposit list and the associated discovery dates have been derived from D.A. Cranstone, An Analysis of Ore Discovery Cost and Rates of Ore Discovery in Canada Over the Period 1946 to 1977, Ph.D. thesis, Harvard University, 1982. Various sources within Energy, Mines and Resources Canada, as well as press clippings and personal contacts, have been utilized in updating the gold deposit discovery list to include 1978-85 discoveries. There is a possibility that some deposits, especially those discovered in more recent years, have been missed. These do not of course appear on our discovery list nor have they been included in our evaluation.

Table 3

TOTAL GOLD EXPLORATION EXPENDITURES
($ 1985 million)

Region	Time Interval					Total
	1946-55	1956-65	1966-75	1976-80	1981-85	1946-85
Appalachian	4	12	7	2	26	51
Quebec	74	67	54	86	365	646
Ontario	62	55	69	82	372	640
Western Shield	24	19	32	44	119	238
Cordilleran	23	15	60	96	260	454
Canada	187	168	222	310	1,142	2,029

The distribution of possible economic discoveries is summarized in table 4. About 31 percent of the discoveries were made in Quebec, and 28 percent in Ontario. Of the total of 134 gold deposits, 62 percent were discovered in the last decade (1976-85), with 37 percent being found in the past five years (1981-85).

Of the 134 possible economic discoveries, 39 are considered to be somewhat questionable cases which some might view as either base metal deposits or as pre-1946 discoveries. They are included here because the associated exploration activity is most likely embodied in the expenditure totals summarized in table 3. Later we will examine the effect of removing these deposits from our listing on discovery costs.

General Market Estimates

There is no getting around the difficulty of forecasting metal market conditions because we have to evaluate which of the 134 discoveries are economic. As we now see, the cost structure of gold exploration is a function of future gold and silver price levels. Metal price projections are made to evaluate the time distribution of revenues for each of the possible economic discoveries.

Metal price is both the most important and the most uncertain variable in assessing the number of economic gold deposits. Therefore, while the appraisal is initially based on expected prices, the number of economic discoveries is also evaluated as a function of price. For this purpose, the expected price outlook is bounded by upper- and lower-limit prices for gold and silver. The prices used are shown in table 5. These price estimates represent

Table 5

METAL PRICE PROJECTIONS
(1985 C$ per ounce)

	Lower-Limit Prices	Expected Prices	Upper-Limit Prices
Gold	350	500	650
Silver	5	8	12

Table 4

POSSIBLE ECONOMIC DISCOVERIES FOR EVALUATION
(number)

Region	Discovery Date					Total
	1946-55	1956-65	1966-75	1976-80	1981-85	
Appalachian	0	0	1	1	5	7
Quebec	4	9	7	11	10	41
Ontario	4	5	4	11	13	37
Western Shield	5	5	1	1	12	24
Cordilleran	1	1	4	9	10	25
Canada	14	20	17	33	50	134

long-term average projections, the period of which is intended to correspond to the productive lives of the gold deposits being evaluated.15

Individual Deposit Estimates

Development and production phase characteristics for each of the possible economic discoveries are evaluated by combining estimates of possible future price levels (shown in table 5) with deposit-specific estimates of recoverable ore reserves, mill recovery factors, mine and mill capacities, capital costs, pre-production development period, and operating costs. These estimates endeavour to portray how each of the possible economic deposits would look today if awaiting development. Those discoveries which on evaluation satisfy the minimum rate of return threshold are considered to be economic for purposes of our assessment.

Recoverable ore reserve estimates are critical to the determination of the economic viability of each gold discovery. Also, these estimates are required to assess the amount of gold which would be recovered in each case. The total recoverable gold content estimated for the 134 possible economic discoveries is summarized in table 6. Of the total recoverable gold content of approximately 71 million ounces, 39 percent is contained in deposits located in Ontario, and 32 percent in Quebec. About 62 percent of the gold is associated with deposits discovered in the last decade (1976-85) of the 40-year study period, with 48 percent contained in deposits discovered during the past five years.

Because the ore reserve estimates are of necessity incomplete, an ore reserve multiplier is assigned to each deposit included in the evaluation. These multipliers are intended to allow for the difference between the gold content estimated on the basis of partial delineation of a deposit and the amount of gold ultimately recoverable.16

15. The gold and silver price projections pertain to refined metal sold in the market. In the case of gold, a fixed charge of $12 per ounce is applied to cover the insurance, transportation, refining and marketing costs associated with converting the impure bullion produced at the mine site to refined metal in the ultimate market.

16. The ore reserve multiplier concept has been developed by Cranstone. See D.A. Cranstone, An Analysis of Ore Discovery Cost and Rates of Ore Discovery in

Table 6

RECOVERABLE GOLD CONTENT IN POSSIBLE ECONOMIC DISCOVERIES
(ounces million)

Region	Discovery Date					Total
	1946-55	1956-65	1966-75	1976-80	1981-85	
Appalachian	0	0	0.1	0.2	2.5	2.8
Quebec	0.8	7.5	4.7	5.3	4.4	22.7
Ontario	0.4	0.8	3.4	1.7	21.2	27.5
Western Shield	1.0	4.7	0.0	0.2	3.0	8.9
Cordilleran	0.2	0.1	2.8	2.6	2.9	8.6
Canada	2.4	13.1	11.0	10.0	34.0	70.5

The sensitivity of gold exploration costs to these multipliers is considered as a study variant.

Gold Exploration Costs for the Base Case, by Region, and as a Function of Price

The base case conditions, used as a standard of comparison with other results, are:

- 134 possible economic gold deposits discovered in Canada during the 1946-85 period,
- expected metal prices,
- 8-percent minimum acceptable rate of return for an economic deposit,
- $5-million annual exploration budget.

Under these conditions, 82 of the 134 deposits are found to be economic. The distribution of the number of economic deposits by region and as a function of price is presented in table 7. For expected prices, the number of economic gold deposits is shown to vary from six in the Appalachian region to 32 in Quebec. As prices are increased from lower-limit to upper-limit levels, the number of economic discoveries increases from 41 to 111.

The total exploration expenditure estimates (table 3) are divided by the number of economic deposits assessed (table 7) to determine the average exploration expenditure required to find and delineate an economic deposit. Results

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Canada Over the Period 1946 to 1977, Ph.D. thesis, Harvard University, 1982. Applying this concept to 21 vein gold mines, Cranstone evaluated multipliers which ranged from a high of 40.7 to a low of 0.5, with a median value of 2.7 and a weighted average value of 6.7. Because of the tendency for more recently developed gold mines to be more extensively delineated by diamond drilling before production begins than in former times, a value of 3.0 was chosen by Cranstone as a typical multiplier to apply to initial ore reserve estimates. Prediction of total minable ore reserves and the associated mine life using multipliers is a particularly difficult task, and, as a result, such estimates should be based on the specific geologic characteristics of individual deposits. For purposes of the present study, the multipliers assigned to particular gold deposits vary from 1.0 to 4.0.

Table 7

NUMBER OF ECONOMIC DEPOSITS DISCOVERED

Region	Lower-Limit Prices	Expected Prices	Upper-Limit Prices
Appalachian	4	6	7
Quebec	12	32	36
Ontario	10	20	32
Western Shield	7	12	19
Cordilleran	8	12	17
Canada	41	82	111

are shown in table 8. The Canada-wide average at expected prices is $25 million, varying from $8 million in the Appalachian region to $38 million in the Cordilleran region. As future price projections are increased from lower-limit to upper-limit levels, the average exploration expenditure per economic discovery is shown to decrease from $49 million to $18 million.

Table 8

AVERAGE EXPLORATION EXPENDITURE PER ECONOMIC DEPOSIT DISCOVERED
($ million)

Region	Lower-Limit Prices	Expected Prices	Upper-Limit Prices
Appalachian	13	8	7
Quebec	54	30	18
Ontario	64	32	20
Western Shield	34	20	12
Cordilleran	57	38	27
Canada	49	25	18

The recoverable gold content in the economic deposits discovered is presented in table 9. The gold content per economic discovery, averaging about 756,000 ounces at ex-

Table 9

RECOVERABLE GOLD CONTENT IN ECONOMIC DISCOVERIES
(ounces million)

Region	Lower-Limit Prices	Expected Prices	Upper-Limit Prices
Appalachian	1	3	3
Quebec	12	22	22
Ontario	21	23	27
Western Shield	2	7	8
Cordilleran	6	7	8
Canada	42	62	68

pected prices, varies from 37,000 ounces for the smallest deposit, to 18.3 million ounces for the singular Hemlo discovery. Thus, Hemlo accounts for about 80 percent of the economically recoverable gold discovered in Ontario at expected prices, and about 30 percent of the Canadian total. As prices are increased through the projected range (table 5), the recoverable gold content in economic discoveries increases from 42 million ounces to 68 million ounces.

Undiscounted exploration costs per ounce of gold recovered are determined by dividing total exploration expenditures (table 3) by recoverable gold content in the economic discoveries (table 9). The resulting discovery costs are shown in table 10. Exploration expenditures expressed in this way average $33 per ounce at expected prices, varying from $20 per ounce in the Appalachian region, to $66 per ounce in the Cordilleran region. As possible future prices are increased from lower-limit to upper-limit levels, the undiscounted discovery cost falls from $48 to $30 per ounce.

While the discovery costs summarized in table 10 may appear modest, this type of indicator (used by Schreiber and Emerson, and others) neglects the costliest aspect of mineral exploration - the long, uncertain time lag between the expenditure of exploration funds and the recovery and sale of gold contained in the associated economic discoveries.

Table 10

UNDISCOUNTED GOLD EXPLORATION COSTS
($ per recoverable ounce discovered and delineated)

Region	Lower-Limit Prices	Expected Prices	Upper-Limit Prices
Appalachian	50	20	18
Quebec	54	30	29
Ontario	31	28	24
Western Shield	99	32	24
Cordilleran	75	66	58
Canada	48	33	30

Application of the methodology employed in this paper, incorporating time value, generally assumes expected metal prices, an 8-percent minimum return requirement on exploration funds, a $5-million annual exploration budget, and a 3-year mine development period. The resulting time-adjusted discovery costs are presented in table 11. Gold exploration costs for Canada are found to average $111 per ounce, varying from $50 per ounce in the Appalachian region to $242 per ounce in the Cordilleran region.

Table 11

TIME-ADJUSTED GOLD EXPLORATION COST BY GEOGRAPHIC REGION
($ per recoverable ounce discovered and delineated)

Region	Time-Adjusted Gold Exploration Cost
Appalachian	50
Quebec	90
Ontario	118
Western Shield	89
Cordilleran	242
Canada	111

Gold discovery cost assessments as a function of the lower-limit, expected value, and upper-limit metal price conditions specified in table 5 are shown in table 12. These results illustrate the high degree of sensitivity of discovery costs to metal price conditions.

Table 12

METAL PRICE VARIANTS

Region	Time-Adjusted Gold Exploration Cost ($ per ounce)		
	Lower-Limit Prices	Expected Prices	Upper-Limit Prices
Appalachian	137	50	44
Quebec	291	90	83
Ontario	229	118	81
Western Shield	274	89	68
Cordilleran	385	242	176
Canada	251	111	89

Findings for lower-limit prices are alarming. As prices increase, gold exploration costs decline from $251 per ounce on average at lower-limit prices to $89 per ounce at upper-limit prices. This trend results from the underlying increase in the number of economic deposits and, hence, the recoverable gold content (as shown in tables 7 and 9). At the same time, higher metal prices reduce the average exploration expenditure and the average time required to discover and delineate an economic deposit.[17]

Cost-of-Capital Variants

To analyze the sensitivity of results to minimum acceptable profitability, the cost of capital is varied from 5 percent to 15 percent. Results are given in table 13. As the minimum rate-of-return requirement is raised, gold exploration costs increase dramatically from $71 to $349 per ounce.

17. This is because more discoveries satisfy the "economic deposit" definition, and not because of an integral change in the exploration process.

Table 13

COST-OF-CAPITAL VARIANTS

Cost of Capital	Time-Adjusted Gold Exploration Cost ($ per ounce)
5 Percent	71
8 Percent	111
10 Percent	155
15 Percent	349

Variants with Respect to the Annual Exploration Budget

An annual exploration budget of $5 million, considered to be a most efficient rate of expenditure, is incorporated in the base case. Assessments have also been made for annual exploration budget rates of $2.5 million and $10 million. Gold discovery costs for these variants are presented in table 14. Since it reduces the average exploration time required to find and delineate an economic gold deposit, an increase in the annual exploration budget has a strong effect on lowering the time-adjusted exploration cost, from $162 per ounce at the $2.5 million annual budget rate to $91 per ounce at the $10 million per year rate.

Table 14

VARIANTS WITH RESPECT TO THE ANNUAL EXPLORATION BUDGET

Annual Exploration Budget	Time-Adjusted Gold Exploration Cost ($ per ounce)
$2.5 Million	162
$ 5 Million	111
$10 Million	91

Time Trends

Time trends in gold exploration costs are analyzed through a comparison of results for five selected intervals within the 40-year study period: the three decades 1946-55, 1956-65, 1966-75, and the two five-year intervals 1976-80, and 1981-85. Findings, presented in table 15, show the interplay of two dynamic forces which underly the gold supply process: depletion effects and advances in geoscience concepts and exploration technology. With the exception of the initial 1946-55 interval, discovery costs appear to be increasing, from $37 per ounce in 1956-65, to $156 per ounce in the most recent 1981-85 interval. This suggests that improvements in applied geology have not been able to offset the negative consequences of depletion.

Influence of Deposits Which Could be Viewed as Either Base Metal Deposits or Pre-1946 Discoveries

The effect of removing deposits from the data base which could be considered either base metal deposits or pre-1946 discoveries is illustrated in table 16. Through this adjustment of the data base, the average cost of discovering an ounce of gold increases from $111 to $157.

Table 16

EFFECT OF DEPOSITS WHICH COULD BE VIEWED AS EITHER BASE METAL DEPOSITS OR PRE-1946 DISCOVERIES

	With These Deposits	Without These Deposits
Number of economic discoveries	82	59
Exploration expenditures per economic discovery ($ million)	25	34
Recoverable gold content in economic discoveries (ounces million)	62	52
Undiscounted exploration cost ($ per ounce)	33	39
Time-adjusted gold exploration cost ($ per ounce)	111	157

Table 15

TIME TRENDS

	Time Interval					Total
	1946-55	1956-65	1966-75	1976-80	1981-85	1946-85
Number of economic discoveries	9	15	9	18	31	82
Exploration expenditures per economic discovery ($ million)	21	11	25	17	37	25
Recoverable gold content in economic discoveries (ounces million)	2	13	8	8	31	62
Undiscounted exploration cost ($ per ounce)	97	13	29	40	36	33
Time-adjusted gold exploration cost ($ per ounce)	225	37	97	100	156	111

Effect of Ore Reserve Multipliers

The effect of applying ore reserve multipliers, specifically estimated for each deposit, to allow for the difference between gold content estimated on the basis of partial delineation of a discovery and the amount of gold ultimately recoverable is presented in table 17. The overall impact of applying these multipliers is to increase the estimated recoverable gold content for the 82 deposits which are evaluated as economic at expected prices from 62 million ounces to 108 million ounces or, in other words, by 74 percent. Consequently, the time-adjusted exploration cost is reduced from $111 per ounce to $84 per ounce. The time-adjusted effect of the multipliers is relatively modest (a 24 percent reduction in cost in this case) because the ounces added are only recovered in the later years of mine life.

Table 17

EFFECT OF ORE RESERVE MULTIPLIERS

	Without Multipliers	With Multipliers
Recoverable gold content in economic discoveries (ounces million)	62	108
Undiscounted exploration cost ($ per ounce)	33	19
Time-adjusted gold exploration cost ($ per ounce)	111	84

Effect of the Hemlo Deposit

The effect of the Hemlo deposit is analyzed by hypothetically removing it from selected study assessments (table 18). Without Hemlo, gold exploration costs in Ontario would increase from $118 to $392 per ounce, and the average cost for Canada would rise from $111 to $143 per ounce. Canada-wide gold discovery costs for the most recent 1981-85 interval are shown to increase from $156 to $279 per ounce. Thus, the Hemlo discovery represents a substantial

Table 18

EFFECT OF THE HEMLO DEPOSIT

	Ontario		Canada		1981-85 Time Interval	
	With Hemlo	Without Hemlo	With Hemlo	Without Hemlo	With Hemlo	Without Hemlo
Number of economic discoveries	20	19	82	81	31	30
Exploration expenditures per economic discovery ($ million)	32	34	25	25	37	38
Recoverable gold content in economic discoveries (ounces million)	23	5	62	43	31	13
Undiscounted exploration cost ($ per ounce)	28	136	33	47	36	87
Time-adjusted gold exploration cost ($ per ounce)	118	392	111	143	156	279

part of Canada's gold endowment. Gold discovery costs in Ontario and for the 1981-85 interval are particularly sensitive to the presence of the Hemlo deposit. The possibility that any exploration program can culminate in this type of multi-billion dollar discovery, although highly unlikely, is no doubt a great motivating force in gold exploration.

Comparison of Study Results with Schreiber and Emerson Estimates: 1961-83 Period

Finally, study estimates are compared with those assembled by Schreiber and Emerson for the 1961-83 period. Results are presented in table 19. The differences are striking. Further work needs to be done to improve the reliability of the data base and findings presented here.

Table 19

COMPARISON OF GOLD EXPLORATION EXPENDITURE ESTIMATES, 1961-83 PERIOD

	Schreiber and Emerson	Present Study
Total exploration expenditures ($ million)	1,825	1,210
Number of economic discoveries	20	59
Recoverable gold content in economic discoveries (ounces million)	27	49
Undiscounted exploration cost ($ per ounce)	67	25
Time-adjusted gold exploration cost ($ per ounce)	356	79

Gold Exploration Costs

Based on the Canada-wide assessments presented in this section as a function of metal prices, the following gold exploration costs are now factored into our determination of the long-term break-even price for Canadian gold supply:

Lower-limit cost - $ 89 per ounce;
Median cost - $111 per ounce;
Upper-limit cost - $251 per ounce.

Long-Term Break-Even Gold Price Requirements

The production, development, and exploration cost components may be summed as shown in figure 6 to determine the long-term break-even price for Canadian gold supply (expressed in constant 1985 Canadian dollars):

Lower-limit price requirement: $278 per ounce;
Median price requirement: $487 per ounce;
Upper-limit price requirement: $838 per ounce.

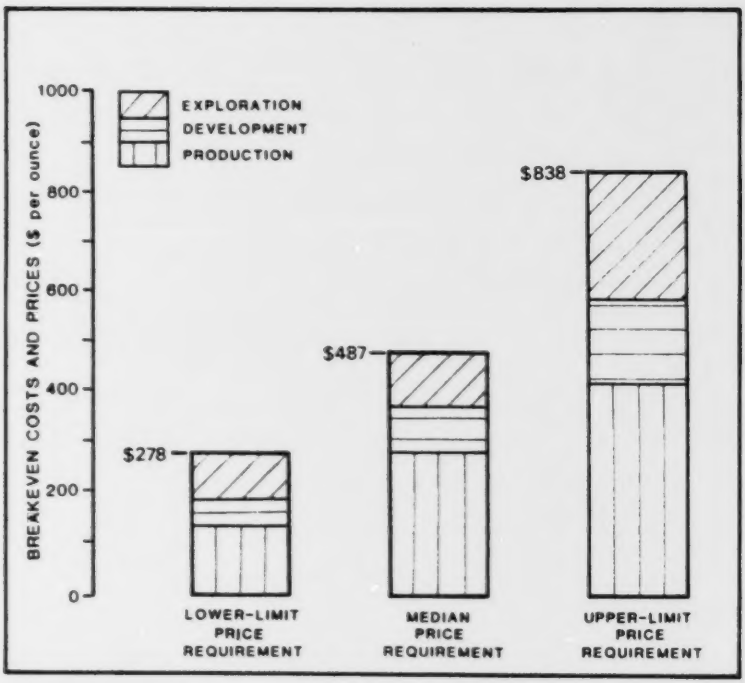

Figure 6. Long-Term Break-Even Price Requirements for Canadian Gold Supply

To the extent that the individual cost components are independent, the limits obtained by combining all the best possible values and all the worst possible values in this way are too extreme. Assuming the three cost components are independent, results have been simulated as follows:

Lower-limit price requirement: $404 per ounce;
Median price requirement: $487 per ounce;
Upper-limit price requirement: $591 per ounce.18

Figure 7 places these results in historical context. As shown, the range of minimum gold price requirements has only ever been attained in recent years.

Economic Justification for Long-term Investment in Canadian Gold Supply

The economic justification for long-term investment in Canadian gold supply requires fulfillment of one of the following conditions:

- a long-term average gold price in excess of the minimum price requirement;

- geological concepts, exploration skills, organizational efficiency, and exposure to geological environments which are sufficiently better than average to reduce a particular company's discovery costs and, thereby, its minimum requirement to an achievable price level;

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18. While the $278 per ounce and $838 per ounce values in figure 6 do represent limits for the break-even price of gold, they are much more improbable limits than the limits specified for the individual cost components. It is extremely unlikely that all the worst-possible or best-possible outcomes for independent variables would occur together. There will tend to be a cancelling out effect. For example, while one cost component may turn out to be on the high side, another may be lower than expected. Thus, the 90 percent limits for the break-even gold price will be closer to the median value than those obtained by combining the individual limits. Overall cost limits have been computed here by applying the Monte Carlo simulation technique to the estimated gold production, development, and exploration cost statistics to estimate the lower-limit and upper-limit values for the break-even gold price requirement.

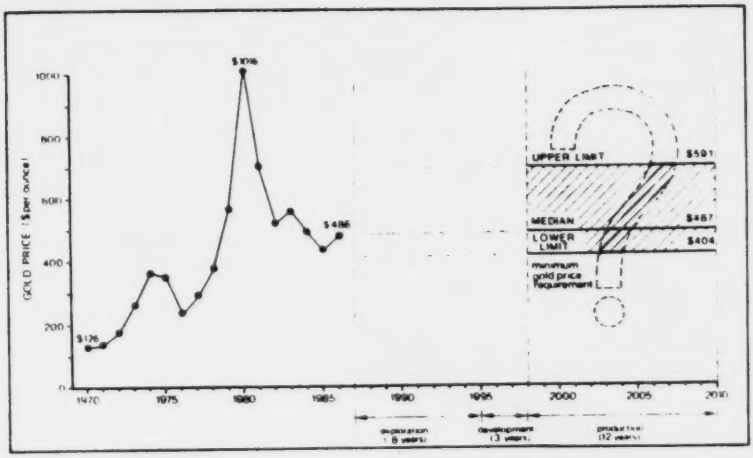

Figure 7. Long-Term Break-Even Price Requirements in Relation to Historical Prices

- engineering, project management, and mine operating skills which are sufficiently better than average to reduce a particular company's development and production costs, and, thereby, its minimum price requirement to an achievable level.

Unfortunately, it is not possible for all companies to be better than average. For the many companies which do not possess the required ingredients for success, the alternatives are simple - either make the required changes to strategy and organizational structure, or, get out of the gold mining business. For the few successful companies, there can be little doubt that long-term investment in Canadian gold supply will prove to be an economically rewarding wealth-creating experience.

If gold market experts do not think long-term prices will satisfy the minimum range of requirements assessed in this study, and if they are right, some tougher more general policy questions arise:

i What explains the extraordinarily high level of gold exploration taking place in Canada at the present time?

ii To what extent are short-term corporate forces and government policies promoting uneconomic behaviour?

iii What will be the long-term consequences of this present behaviour?

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APPENDIX I

GOLD EXPLORATION EXPENDITURES

Table 20
CURRENT DOLLAR GOLD EXPLORATION EXPENDITURES
($ current thousand)

Year	Region		
	Appalachian	Quebec	Ontario
1946	4	2616	2036
1947	5	1265	1242
1948	4	1344	723
1949	18	1544	866
1950	2	1231	887
1951	35	979	986
1952	166	961	926
1953	327	660	831
1954	214	1536	1232
1955	132	314	790
1956	638	1613	1214
1957	500	887	1481
1958	251	672	850
1959	380	1707	1203
1960	407	1525	915
1961	77	1300	1164
1962	51	2159	1800
1963	118	2787	1062
1964	73	1555	1519
1965	198	1307	1602
1966	156	1091	1501
1967	179	1313	1930
1968	148	1318	2016
1969	184	1534	2531
1970	256	1015	3550
1971	116	1188	2386
1972	108	900	1714
1973	288	2600	2636
1974	646	3900	2793
1975	123	4131	1272
1976	81	3672	4542
1977	39	3213	7811
1978	70	6478	8524
1979	100	9743	9236
1980	1199	33946	21549
1981	2297	58149	33861
1982	3434	56679	49956
1983	4571	55209	66052
1984	6067	73272	87664
1985P	7562	91336	109275
Total	31224	438649	444128

P: preliminary estimate

Region		
Western Shield	Cordilleran	Canada
1121	643	6420
999	676	4187
111	319	2501
294	489	3211
133	503	2756
122	292	2414
122	391	2566
493	262	2573
283	135	3400
85	140	1461
509	291	4265
373	131	3372
225	249	2247
267	91	3648
732	236	3815
849	273	3663
435	549	4994
331	408	4706
300	582	4029
436	793	4336
478	1400	4626
359	1349	5130
706	1145	5333
923	1758	6930
1420	2250	8491
1028	1601	6319
847	1520	5089
1087	2556	9167
2767	2643	12749
1766	4427	11719
1560	4612	14467
1353	4797	17213
4340	9391	28803
7326	13985	40390
14297	28764	99755
21269	43544	159120
19148	41012	170229
17026	38480	181338
22596	51070	240669
28167	63660	300000
156683	327417	1398101

Table 21
CONSTANT DOLLAR GOLD EXPLORATION EXPENDITURES
($ 1985 thousand)

Year	Region		
	Appalachian	Quebec	Ontario
1946	30	19515	15189
1947	34	8665	8508
1948	24	8212	4418
1949	105	9032	5066
1950	12	7041	5074
1951	180	5022	5058
1952	817	4728	4556
1953	1586	3201	4030
1954	1053	7557	6061
1955	636	1514	3808
1956	2967	7500	5645
1957	2275	4036	6739
1958	1127	3017	3817
1959	1672	7511	5293
1960	1766	6618	3971
1961	333	5629	5040
1962	218	9219	7686
1963	494	11677	4450
1964	299	6360	6212
1965	784	5176	6344
1966	591	4135	5689
1967	653	4792	7044
1968	523	4653	7117
1969	622	5185	8555
1970	827	3279	11466
1971	363	3721	7473
1972	322	2682	5108
1973	786	7098	7196
1974	1531	9243	6619
1975	263	8840	2722
1976	158	7160	8857
1977	71	5848	14216
1978	119	11013	14491
1979	155	15102	14316
1980	1667	47185	29953
1981	2871	72686	42326
1982	3915	64614	56950
1983	4937	59626	71336
1984	6370	76936	92047
1985P	7562	91336	109275
Total	50718	646364	639721

P: preliminary estimates

Region		
Western Shield	Cordilleran	Canada
8363	4797	47894
6843	4631	28681
678	1949	15281
1720	2861	18784
761	2877	15765
626	1498	12384
600	1924	12625
2391	1271	12479
1392	664	16727
410	675	7043
2367	1353	19832
1697	596	15343
1010	1118	10089
1175	400	16051
3177	1024	16556
3676	1182	15860
1857	2344	21324
1387	1710	19718
1227	2380	16478
1727	3140	17171
1812	5306	17533
1310	4924	18723
2492	4042	18827
3120	5942	23424
4587	7268	27427
3220	5014	19721
2524	4530	15166
2967	6978	25025
6558	6264	30215
3779	9474	25078
3042	8993	28210
2462	8730	31327
7378	15965	48966
11355	21677	62605
19873	39982	138660
26586	54430	198899
21829	46754	194062
18388	41558	195845
23726	53623	252702
28167	63660	300000
238259	453508	2028570

APPENDIX II

POSSIBLE ECONOMIC DISCOVERIES FOR EVALUATION

Appalachian Region

Name	Discovery Date
BEAVER DAM*	1985
CAPE RAY	1977
CAPE SPENCER	1982
COCHRANE HILL*	1973
FOREST HILL*	1983
HOPE BROOK (CHETWYND)	1984
MURRAY BROOK*	1985

Quebec Region

Name	Discovery Date
ASTORIA*	1980
AUGMITTO	1979
BACHELOR LAKE	1947
BEACON	1980
BOUSQUET	1976
BOUZAN*	1955
CALLAHAN*	1981
CAMFLO	1962
CHIBEX (MESTON)*	1950
CHIMO	1963
CONSOLIDATED CENTRAL CADILLAC*	1968
COOKE*	1968
DESTOR	1974
DOYON	1973
DUMAGAMI*	1963
DUMONT	1974
EAGLE-TELBEL	1965
EASTMAIN	1983
ELDRICH	1946
ELLISON	1980
FERDERBER	1977
GOLDEN HOPE* (ESTRADES)	1985
GOLDEN POND	1981

* Deposits which could be viewed as either base metal deposits or pre-1946 discoveries.

Quebec Region (continued)

Name	Discovery Date
GOLDEX	1965
GWILLAM*	1973
HEVA*	1980
KIENA	1961
LAC SHORTT	1979
MALARTIC HYGRADE	1959
MARBAN	1960
MONTAUBAN*	1979
MONTAUBAN SOUTH	1984
NEW PASCALIS	1982
NORBEAU*	1980
NORLARTIC*	1981
NORTH PASCALIS	1982
ORENADA 4	1980
OTISH MOUNTAIN	1983
RIBAGO-SILIDOR*	1985
S-3	1965
SLEEPING GIANT	1976

Ontario Region

Name	Discovery Date
ANNCO	1964
AQUARIUS*	1980
BELL CREEK	1980
BROULAN REEF	1948
CAMERON LAKE	1980
CARSHAW	1980
CLAVOS	1983
DAVIDSON-TISDALE*	1983
DETOUR LAKE	1974
DONA LAKE	1983
FAVOURABLE LAKE*	1960
GOLDEN PATRICIA	1985
GOLDEN ROSE*	1982
H.G. YOUNG	1948
HEMLO (Corona, Golden Giant, and Williams mines)	1981
HIGHLAND CROW*	1981
HOLLOWAY	1984
HOYLE POND	1979
HUGH PAM	1948
KREMZAR*	1983

Ontario Region (continued)

Name	Discovery Date
MAGNINO	1984
MATHESON EAST	1985
MCBEAN*	1977
MCDERMOTT	1982
MISSANABIE*	1949
MITSUBISHI LAKE	1984
NIGHTHAWK LAKE	1980
OPAPAMISKAN (MUSSELWHITE)	1980
OROFINO*	1978
OWL CREEK	1966
ROBIN RED LAKE	1962
ROMFIELD* (VEDRON)	1980
ST ANDREWS	1973
SCADDING	1977
SHOAL LAKE (DUPORT)	1974
SURLURGA* (PANGO)	1964
WILMAR	1960

Western Shield Region

Name	Discovery Date
BULLMOOSE (TERRA)	1981
CORONATION GULF	1964
COURAGEOUS LAKE	1983
CULLATON LAKE	1961
FARLEY LAKE (WENDY)	1985
INDIN LAKE	1984
KOMIS (WADDY)	1980
LOLOR	1964
LUPIN	1960
MACLELLAN (AGASSIZ)	1965
MAHOGANY* (JOLU)	1985
PUFFY LAKE	1981
RIO* (FLIN FLON)	1970
SALMITA	1974
SEABEE	1949
SHERRGOLD	1984
SQUALL LAKE	1946
STAR LAKE	1982
SUPERCREST	1946
TARTAN LAKE	1984
TOWER LAKE EAST	1984
TUNDRA	1946
WEDGE LAKE	1982
WEEDY LAKE	1982

Cordilleran Region

Name	Discovery Date
AYLWIN	1984
BAKER	1968
BIG MISSOURI*	1980
BLACKDOME	1979
BRANDYWINE*	1972
BROWN MCDADE	1946
CARIBOU	1979
CAROLIN	1973
CONSOLIDATED CINOLA	1975
ERICKSON	1977
GOLDEN BEAR	1981
KETZA	1983
LARA*	1985
LAWYERS	1980
MASCOT* (NICKEL PLATE)	1980
MOUNT NANSEN	1965
MOUNT SKUKUM	1981
REA*	1983
REG*	1981
RICHFIELD	1980
SILBAK*	1983
SULPHERETS	1985
TEL	1980
TILLICUM	1980
TOODOGGONE (ENERGEX)	1984

Rejected Deposits

Name	Region
ABINO	Ontario
ARCTIC GOLD	Cordilleran
ARSENAULT LAKE	Quebec
ARSENO	Western Shield
BEGGS LAKE	Ontario
BOSTON TOWNSHIP	Ontario
BROSNAN	Quebec
CAMLAREN	Western Shield
CAMRECO	Ontario
CANRAY	Quebec
CANREOS	Ontario
CAPOOSE LAKE	Cordilleran
CASS ZONE	Western Shield
CITY OF PARIS	Cordilleran
COPCO	Cordilleran
COSEGO	Quebec
COURVAN	Quebec
CUSAC	Cordilleran
DALEMBERT	Quebec
DARIUS	Quebec
DESJARDINS TOWNSHIP	Quebec
DOME MOUNTAIN	Cordilleran
DOUAY TOWNSHIP	Quebec
DOVERCLIFF	Quebec
DUSTY MAC	Cordilleran
EGO	Ontario
ELMTREE	Appalachian
FABRIEN	Quebec
FIFTEEN MILE STREAM	Appalachian
FLORIDAN	Quebec
FRASER GOLD	Cordilleran
FRENCH	Cordilleran
GARNEY	Quebec
GARRISON	Ontario
GOLD SEARCH	Quebec
GOLDSTACK	Quebec
HOSCO	Quebec
HYCROFT	Cordilleran
IMPERIAL	Cordilleran
J & L	Cordilleran
JEEP	Western Shield
JOUBI	Quebec
KENVILLE	Cordilleran

Discovery Date	Reason for Exclusion
1975	insufficient information
1965	too small
1973	too small
1946	too small
1959	too small
1980	too small
1980	insufficient information
1974	too small
1980	insufficient information
1976	insufficient information
1946	insufficient information
1979	too low grade
1986	1986 discovery
1968	insufficient information
1959	too small
1982	insufficient information
Pre -1975	too small
1985	too small
1982	insufficient information
1974	old mine reworked
1955	too small
1986	1986 discovery
Post-1974	insufficient information
1979	insufficient information
1968	too small
1961	insufficient information
1985	too small
1982	insufficient information
1985	too small
Post-1974	too small
1983	insufficient information
1950	too small
1961	too little information
Pre -1970	too small
1980	insufficient information
1981	insufficient information
1982	old discovery
1985	too low grade
Post-1974	too small
1983	base metal deposit
1947	too small
1973	too small
1946	too small

Rejected Deposits (continued)

Name	Region
KEN-CHIB	Quebec
KLOTZ LAKE	Ontario
LAC MONTIGNY	Quebec
LACANA	Cordilleran
LOUANNA	Ontario
LYNDHURST	Quebec
MALARTIC	Quebec
MALARTIC HYGRADE NEW	Quebec
MALARTIC HYGRADE NO. 8	Quebec
MATTAWASAGA	Ontario
MONIQUE	Quebec
MOSQUITO CREEK	Cordilleran
NEW PRIVATEER	Cordilleran
NOKOMIS LAKE	Western Shield
NORRIS LAKE	Western Shield
NORSTAR	Ontario
NUTTLUDE	Cordilleran
OKENADA	Quebec
OROSTAR	Ontario
ORPIT	Ontario
PANDORA	Quebec
QUESABE	Quebec
RAND MALARTIC	Quebec
RED CLAIM	Western Shield
REMINOR	Quebec
RESERVE LAKE	Ontario
SAPAWE	Ontario
SCOTTIE	Cordilleran
SHEAR LAKE	Western Shield
SHE-SHAS	Cordilleran
SHINING TREE	Ontario
SMITH NASH	Cordilleran
SNOPPY LAKE	Ontario
SOISSAN	Quebec
TAURUS	Cordilleran
VAL ST. GILLIS	Quebec
VALIENT	Quebec
VAMP LAKE	Western Shield
VAUGUELIN	Quebec
VENUS MINES	Cordilleran
VINRAY	Quebec
VOL	Western Shield
WADEK BAY	Western Shield
WESTERN QUEBEC	Quebec
WRIGHTBAR	Quebec

Discovery Date	Reason for Exclusion
1955	insufficient information
1983	insufficient information
Post-1974	insufficient information
1985	insufficient information
1946	too small
1951	too small
1982	too low grade
1986	1986 discovery
1985	insufficient information
1984	insufficient information
1983	insufficient information
1973	too small
1983	too small
1960	too small
1946	too small
1958	too small
1979	too low grade
1974	insufficient information
1974	too small
1973	insufficient information
1980	insufficient information
1947	too small
1985	too small
1985	too small
Pre- 1946	Horne deposit reworked
1960	too small
1960	too small
1944	pre-1946 discovery
1983	uneconomic
1983	insufficient information
1984	insufficient information
1960	insufficient information
1986	1986 discovery
1981	insufficient information
1979	too small
1979	too small
1964	too small
1964	insufficient information
1964	too small
1966	too small
1946	too small
1962	too small
1952	copper deposit
1979	insufficient information
1986	1986 discovery

FLOW-THROUGH SHARE FINANCING

Basil Kalymon

Introduction

The financing technique of flow-through shares has become a significant factor in the financing of mineral exploration, and, in particular, of gold exploration in Canada. This paper will address the Canadian situation, with emphasis on taxation and how it distorts the perception of the investment. A quick background view of the industry is provided, as this is important in understanding why flow-through shares became so widespread. Alternative innovative forms of financing will also be discussed. The investment structure will be considered from a corporate and then from a investor's point of view.

Flow-through shares may be defined as an interest acquired in a mining venture in which tax deductions resulting from the expenditures of the invested funds are attributed (or "flow through") to the original investor on whose behalf the activity is undertaken. The basic concept of the flow-through share, as it operates in Canada, is that exploration expenditures may be deducted from taxable income at a 100 percent rate and in the year of expenditure. There is an earned depletion of 33 1/3 percent which can also be deducted up to 25 percent of taxable income. Thus, these two provisions permit deductions which essentially constitute 133 percent of the expenditure for exploration. These tax write-offs create a very powerful incentive for financial restructuring which will enable their immediate realization.

Non-taxable corporations, however, clearly cannot utilize deductions immediately and much of the industry has recently found itself in a nontaxable position. The flow-through share concept became possible in 1972, but became attractive only after the tax laws were changed in 1983 permitting corporations to transfer deductions for exploration and depletion to investors - in other words, to take the write-offs from within the corporation and essentially transfer them out to investors. Investors earn flow-through shares in the corporations for the investment made, and those investments are assumed to be going into exploration. Once the deductions have been made, flow-through shares are just regular common shares of the corporation.

When investors earn flow-through shares, they also pick up the deductions that relate to the expenditures - and these deductions may be applied to personal income. This basic structure, which evolved around 1983, made it possible for the flow-through share financing vehicle to evolve in the post-1983 period.

The Mining Industry and the Development of Flow-Through Shares

Why did flow-through shares evolve? We know that they evolved right around the time when the Canadian metal mining industry's sales and revenues were crashing, and the larger producers were in a non-taxable position. Taxes are the key to the whole question and in 1982 the industry as a whole reported a negative tax position. With no taxable income, there was nothing from which exploration expenditures could be deducted. (These remarks apply to an industry average; individual corporations may have been in a different position.)

Except for gold, metal production was pretty stagnant. The precious metals were following a somewhat different pattern, while gold was increasing in terms of dollar value of production and was still an attractive exploration target. Exploration statistics are quite interesting. Exploration really started to fall in 1982, and then in 1983 there was a sharp recovery, clearly related to the interest in gold.

On the financial side, it is interesting to consider the industry assets over this period. First of all, the total assets of the industry started to flatten out in 1982-83. At the same time, there was a substantial surge of additional debt. By 1983 the position of the corporations had deteriorated in terms of the debt equity ratio, and a perceived need for additional equity in the capital structure of mining firms.

What happened in terms of flow-through share financing? How successful has it been? How extensive? How important? The assessment of how much flow-through share financing has occurred is not an easy task, because there are many different bases to consider in trying to identify how much exactly was issued and who issued the shares. For example, companies may announce issues which then don't go through, or they only partially go through with the issues. Probably the best or most consistent source of information for analysis of new issues is the files of the main stock exchanges. The publicly traded companies

issuing flow-through shares must register them. Since most companies are traded and are listed on an exchange, they must report new stock issues through exchange reporting requirements.

In order to qualify as a flow-through share, the proceeds of an issue have to be spent on exploration. There was a slow start of $42 million in 1983, rising to about $309 million in 1985 and, from incomplete results so far, they seem to be really booming still in 1986, with $190 million raised in less than half a year, apparently heading for a substantial increase again in 1986.

An interesting trend that has developed is that the Vancouver stock exchange has moved up very significantly, relative to the major Toronto and Montreal exchanges, in the amount of flow-through shares that have been issued from 1983 to 1986. The Toronto exchange, in terms of absolute level of activities, has moved up significantly, but Vancouver, in relative terms, has moved up quite strongly. The size of flow-through share issues and the time pattern correlate fairly nicely with the exploration expenditure pattern which has occurred. Whether this was due to the availability of flow-through shares is an important policy question. No single factor creates the exploration decision. Obviously, if the fundamental economics of the gold market were perceived to be unfavourable, then this exploration activity would not have occurred. Presumably, favourable economics and the funding by flow-through shares occurred in parallel.

The Distribution of the Size of Flow-Through Shares

With respect to the size of flow-through share issues, I have analyzed the distribution for 1983 to the first part of 1986.

Who was getting this money? In 1983-84, distribution in terms of the number of issues showed that large issues (over $5 million) represented 10 percent of the issues and those between $1 and $5 million represented 19 percent. Seventy-one percent of the issues, however, is below $1 million dollars, with 37.2 percent in the $100,000 to $500,000 range.

Of course, if you consider the dollar amount, the results are significantly different. About 63 percent is accounted for by the big issuers, with issues greater than $5 million. There were many big issues taking a very substantial portion of the available flow-through share funds.

In 1985-86, the percentages for the large issuers has declined, in terms of both the number of issues and the percentage of funds. Both ratios have declined for issues above $5 million to a level of 4.3 percent by issue and 33.3 percent by amount. The drift is in the direction of more junior issuers. Issues below $1 million represented 77.8 percent by number, with 62.8 percent below $500,000 in size.

This shift to smaller issues implies more junior issuers; senior issuers would not be interested in making a $500,000 issue for flow-through purposes. This trend is correlated with the exchanges involved and the relative increase of the importance of Vancouver to this market. Vancouver, with 86.2 percent of issues and 37.1 percent of the amount raised accounted for by issues below $100,000, is different from the other two exchanges. In Toronto, by contrast, only 36.2 percent of all issues and 4.6 percent by amount was in such small issues. In Montreal, the figures were 25 percent of all issues and 6.8 percent by amount in these smaller issues.

For the larger issues, even in Vancouver, there was the odd major company with issues above $5 million in size and this resulted in 27.7 percent of activity by amount for the 1985-86 period. In Toronto or Montreal you can see the dominance of larger equity issues, with 89.2 percent by amount in Toronto and 81.5 percent by amount in Montreal going to issues above $5 million.

The interpretation of this is quite clear: flow-through shares have been attractive to both the large companies and to the juniors - both have utilized the flow-through shares concept. The importance of taxation in this question, however, is critical. The interest of the seniors is clearly coming from their temporary non-taxable position which started around 1982-83 and in some cases still persists. For the juniors, nontaxability is a perennial condition, since, as nonproducers, they do not have taxable income against which write-offs can be applied. To whatever extent there is a drift, it is now towards more junior issues, as the senior companies move back to taxable status.

Alternative Forms of the Flow-Through Share

A number of alternative forms have evolved in this investment market. The traditional issue has always been the direct placement of shares, i.e. shares going out to the investor, either through a private or a public placement mechanism, but nevertheless shares going directly out to

the ultimate investor. This type of activity still accounts for two thirds of the total flow-through share market. The other third includes a variety of new developments, but is dominated by diversified partnerships. Diversified partnerships are created to acquire flow-through shares from many different issuers, and then sell their shares to the ultimate investor. These diversified partnerships, which seem to account for almost one third of the current volume of flow-through share funding, have created very interesting changes to the distribution of risk bearing: who bears the ultimate risk, and the nature of that risk. The major innovation is the diversification aspect. The partnerships effectively create mutual funds for investors in mining ventures. Through these mutual funds, investors can diversify their portfolio and have as many as 20 or 30 companies in the portfolio of shares they are acquiring. In other words, the partnership spreads the risk through many different companies which results in a mutual fund concept of investment in mineral exploration.

One evolution is in fact a mutual fund with redemption rights. The basic structure includes a partnership which acquires the shares of many different companies which then transfers them into a mutual fund. The ultimate investor has a share in the mutual fund and has redemption rights, just as with other mutual funds. The investor can ask for redemption of his shares, but, of course, that has to occur at the market valuation.

A problem arises if too many investors ask for redemptions and the market value becomes unsupportable. Other alternatives try to recognize this scenario and schedule liquidation. The portfolio of shares goes into the partnership to be sold on a scheduled liquidation. Instead of allowing a redemption which is basically dependent on when the investor wants to cash out, there is a lock-in until shares can be sold in an orderly basis. The problem is that many of those buying into these partnership units are buying tax-shelter vehicles and there is some question as to what their holding period really would be. Many investors simply want to get the tax shelter and then sell out, creating a very difficult problem in terms of redemption and putting a lot of market pressure on the issued shares.

An answer to that problem is the distribution of shares to the partners. In place of liquidation, the mutual fund (with many different shares) may distribute to each partner and have each partner worry about the management of his or her liquidity. However, this is a disadvantageous situation, because investors generally avoid dealing with small

holdings in 25 different shares, a messy situation that mutual funds are supposed to avoid by creating a mutual pool.

Another modification is the transfer of shares to a management company, which then manages that portfolio for the investor in an active manner. Associated with this approach is a very major modification in risk bearing: investors are given a "put" option on the management of company shares, under which they have the right to sell their shares after five years at a pre-specified price, which is approximately their after-tax initial acquisition cost. That put option creates liquidity for the investor after five years and creates certainty in the minds of the investors and their investment vehicle. Somebody, however, must underwrite that put option. The companies undertaking the exploration and obtaining the exploration funds have to set aside a portion of the funds in order to guarantee the put option. If exploration activities work out well, then those funds come back to them; if not, the put option is activated and the money is lost to the issuing company.

There is a very clear splitting of who is at risk. The investors in the mutual fund partnership are very clearly not at any risk on the downside because, thanks to the put option, they are basically buying a pure tax shelter. It is a zero sum game; somebody has to bear the risk. In this case, it is borne by the issuing company shareholders. They are the ones who are underwriting the put option and they are the ones risking their own capital in the event of failure.

Investment From a Corporate and Investor's Point of View

Let's look at the question of tax equity. A lot of the discussion of flow-through shares surrounds the questions of what is fair and what is not, why this is happening, and does it make sense. From a social point of view, present value computations can ignore taxes. From an investor's point of view, you cannot ignore taxes because they effect the ultimate return on the investment. That is the bottom line: what happens to you after tax.

Corporate View

I have not tried to study the basic tax rules in the industry, whether they are fair or not, or start from a position of equity. Rather, I am trying to compare the situation for

a company in which exploration is internally deductible, with the situation for a company in which the exploration deductions are renounced to somebody else. The two cases vary with tax position, i.e. whether or not a company has taxable income. The non-taxable group includes senior non-taxable companies and all juniors. The effect of renunciation on investment incentives can be very striking. What I have analyzed is the ratio of the present value of a project to the original cost. The analysis considered a simple typical exploration/development project, an average type of marginal project. This project was analyzed on a cash flow model on a 13-year project life basis.

A successful venture, assumes that an economic deposit is found and developed. For a taxable firm, the ratio of present value to investment, i.e. the go situation for a successful venture, was found to be 1.30.

Alternatively, one can analyze the same situation for the company with no initial taxable income. In this case the cost-benefit ratio is only 0.72 and the return works out to be less than the cost of investment. Basically the difference between these two examples is that the second company initially does not get the tax benefits of the deductions. If the company does get to deduct, it does so well down the line and misses all the front end value of the write-off.

These cost-benefit ratios are even more interesting if the project is unsuccessful - if you spend your money up front and then find nothing. Here the ratios are really startling, because if you are taxable, you still keep about 64 percent of the invested amount. If, however, you are non-taxable, the result is a real bust situation. Everything is lost because you have no deductibility to shelter you.

The relative disadvantage of the taxation framework in taxable/non-taxable environments is obvious. If you then look at the situation where you renounce the deductions and go to the outside, then that disadvantage is essentially or significantly reduced. If the venture is successful, the cost-benefit ratios within the companies are 0.65 and 0.45 respectively for taxable and non-taxable companies. If the project is unsuccessful, both firms lose all the investment.

It is clear that the ability to renounce deductions provides a much more neutral tax structure. It is a neutralization of the relative advantages of taxable and non-taxable companies in undertaking projects.

Individual Investor's View

Now consider the investment decision from the point of view of the shareholder. There is so much misinformation about what is a flow-through share and who bears the risk when you get to the investor side of the picture. The way to look at these incentives is to link the corporate model with the investor economics to see what happens. What I did is to analyze what occurs when you buy shares.

Flow-through shares are dangerously promoted as being sold at market value, but, thanks to a big tax write-off, you are actually buying well below market value and have an automatic gain. The usual analysis assumes you buy at market price. Let's say you buy shares at $10,000, and because of depletion allowances you get $12,840 in tax deductions. If your personal tax rate is in the 55-percent category, you get a tax shield of $7,062, and the after-tax cost of investment is about $2,938. The usual promotion suggests that you are going to sell the shares at the market for $10,000. You are going to have proceeds of $10,000. Then your total returns are $7,062, which is the difference between $10,000 and your after-tax costs. Assuming that you still haven't utilized your capital gains exemption, then you have no taxable capital gains or you have a capital gains tax of zero, which means that you get a return of $7,062 on the investment. Assume, normally, you are tied up for a year with all the escrowed stock. So you get a beautiful return of 240 percent. This is a promotional analysis of what returns are available.

The reality, however, is different - and there are two realities. The first, relating to investment in the flow-through shares of senior companies, is a major reason why flow-through shares became so quickly accepted by the market and were picked up so heavily. When you buy into the mutual funds where seniors are the major component of the portfolio, you are buying a blend of exploration risk and all other activities that are going on in the company, namely the production side of the business. Even though your money is going to exploration, you are earning a common share of the firm which benefits from the total activities, a share which is not specific to the exploration results that are achieved - a very important qualifier.

Suppose that the existing activity ratio is about 80 percent producing mines and only 20 percent of your results are going to depend on the exploration venture activities. Even that is probably an understatement of what would be true in a large senior company. Assuming 80 percent of the results are relatively predictable, then 80

percent of your share value is protected. When you go to sell, you are probably going to realize most of the existing price, because 80 percent of your price has been predetermined by existing production.

Suppose specifically that the exploration venture is "successful", then for the senior investment a blend of 80 percent of the existing market price and 20 percent of the venture value gets you about a $9,961 realization. Now senior companies are rational; they know that they are giving you a large benefit when they give you the write-off associated with exploration, so they take a premium. Senior flow-through shares will sell at a significant premium over market price because of the transfer of the tax write-off. In this case you pay a premium, but even assuming a premium of 50 percent, the investment still has a pretty attractive return.

Now picture the second reality. If you go through the calculation assuming the investment is in a junior exploration company, the results are very different. The flow-through shares portfolios now appearing are heavily oriented to the junior side. Suppose you bought the shares at $10,000. When you come to sell the shares, the value will totally depend on the success of the exploration ventures that the company is undertaking. In this example I have used the present value of the "successful" project, which comes out to be about $4,501, to represent the selling value of the shares. Now that number could be anywhere from zero to a very high number. It is probably zero most of the time because of the low chances of exploration success, and it is a very high number on occasion. My point here is that you are directly linked to the exploration risk through the exploration activities. In this case, even if no "premium" is paid, assuming a successful venture, the investor will earn a return of about 53.2 percent.

If the venture is unsuccessful, the two situations - investment in a senior or in a junior company - look strikingly different. The investor is still going to get a good return from the senior because the investment is in the basic underlying value of the producing mines, so that $8,000 is still realized on the sale. In the junior, however, you are out of money completely, with a zero sale value. In this case, you can never make money on the tax shelter alone. You have reduced your after-tax cost to $2,938, but this money is still lost if the venture fails. With a junior company, you always lose if the venture is unsuccessful.

Now just for comparison, I wanted to point out that if you do not have transferability of deductions, if you do not

allow personal tax shielding, then the venture, even if so-called "successful", looks poor from the perspective of an investor in a junior company. Again, I found that for the taxable senior, the investor will still generate some return due to the higher internal value of the project.

Conclusions

To summarize, here are two conclusions in terms of present trends and future indications. First of all, I believe there has been a very significant impact on the financing of exploration by flow-through shares. The non-taxable position of both the producing industry and the non-taxable juniors has played a significant role in the attractiveness of the investment vehicle. There has been a significant increase in exploration expenditures and exploration activity. They have appealed to both junior and non-taxable seniors, but as the seniors move closer to a taxable position, the attraction of issuing flow-throughs decreases or disappears. Only the non-taxable companies are really interested in flow-throughs. With an economic recovery, there will be a drift away from flow-through shares and an overall decline in levels of funding from this source.

The shift to juniors is already occurring, and I do not think the investor market yet fully realizes the implications of this phenomenon. Even if you put 20 junior companies into a portfolio, you are not going to diversify exploration risks effectively. When investor risk is modified, the tax department often calls it abuse. Half the time the difference between incentive and abuse is just a matter of which year you are considering - the introductory year or a couple of years later. There are, of course, possibilities of fraud, through, for example, high write-offs or artificially inflated costs. It is a pure question of audit as to whether the funds are properly used.

On the other hand, what some consider abuses, I consider innovations in the capital markets - the "put" option innovation for example. In this case, somebody is bearing the risk as long as the exploration costs are legitimate. This is a very innovative way of parcelling out risk. The capital markets are filled with innovative ways of packaging risk and risk bearing to transfer the tax loss from one agent to another.

Diversification can reduce junior risk, but not eliminate it, and this will be a problem. There is a limit, ultimately, to the amount of risk bearing in the market. You have to attract the high-risk investors, those who really

want to take exploration risk. This is a smaller market than the tax-loss investor market.

The government is clearly getting edgy about the tax revenue loss, but flow-through shares were brought in basically as a support for the industry, and I suspect that as long as the industry is in a weak position this support will not be withdrawn. The chances for elimination will be greater if or when the industry comes into profitability.

Flow-through shares do neutralize the tax advantages of senior companies over junior companies, making the juniors more attractive as investment opportunities. The junior sector is very important in the exploration phase, and that is where tax-loss transfer will continue to be very important. The market for junior shares, however, is limited, as there is still a real risk element, in spite of the tax transfer. I would say that the flow-through share market is going to decline naturally, in terms of the seniors, and that the risk aspects will limit its use by juniors in the future.

THE GOLD MINING BUSINESS IN BRAZIL

Claudio Margueron

In the 18th century Brazil was the world's largest gold producer; today it has surpassed Canada and taken third place, after South Africa and the USSR, in world gold production. By the year 2000, estimates point to a gold output of the order of 200 tonnes per year. Brazil is definitely gearing up for one of history's biggest gold rushes.

Brazil's Existing Reserves and Future Potential

The sources of gold on Brazilian shield areas are largely unexplored greenstone belts of Precambrian rock, like those in known shield areas of South Africa, Canada, Australia, and the USSR from where most of the current world gold is produced. Brazilian geological gold reserves, estimated at 32,000 tonnes, are probably larger than the 25,000 tonnes known to be present in South African reserves.

Brazilian in-place geological gold reserves are located as follows: 45 percent in the north, 7.3 percent in the northeast, 44 percent in the central west, and 3.7 percent in the southwest.

Seventy percent of the currently known Brazilian gold reserves are estimated to be alluvial (secondary) deposits which can be mined by mechanized, semi-mechanized and manual methods. The remaining 30 percent are primary gold deposits occurring in hard rock environments requiring underground mining methods for production.

The most attractive regions to be studied for the expansion of gold reserves are the north and central west regions which have large alluvial deposits in the following areas: Rio Madeira, Rio Tapajos, Andorinhas, Cumaru, Serra Pelada, Alta Floresta, Curupi, and new reserves in Crixas, Carajas and Jacareacanga.

Brazilian gold production is compared to that of other major world producers in table 1.

Specifications for gold are usually stated in terms of fineness; thus 999 fine (the commercial grade) means 999 of actual gold content per 1,000, or 99.9 percent. Brazilian Mining Institute (IBRAM) projections estimate that by 1990 total Brazil new fine gold production will be 72.03 tonnes (up almost 9 tonnes from the 63.29 tonnes estimated for

Table 1

GOLD PRODUCTION BY MAJOR PRODUCERS
(tonnes)

	1970	1975	1980	1983	1984	1985	1990[e]	1995[e]	2000
S.Af.	1000	713	675	660	650	650	600	500	460
USSR	347	468	400	312	300	300	300	300	300
Brazil	9	12	35	47	55	63	72	200	350
Canada	75	51	49	64	64	64	70	70	70
World Total	1638	1442	1363	1417	1450	1500	1550	1600	1650

[e] = estimate

1985). Of this total production, IBRAM estimates that the number of garimpo registered and nonregistered mines will drop their contribution from a peak of 55.1 tonnes mined in 1985 to a low of 42 tonnes in 1990.

Garimpeiros and The Evolution to Modern Mining Techniques

More than 85 percent of Brazil's current gold production now comes from "garimpos", large areas of surface and near-surface gold deposits usually worked by individuals known as "garimpeiros" (or pick-and-shovel miners). There are probably some 1 million garimpeiros active in Brazil. Most of the current Brazilian gold production is estimated to come from garimpeiros located mainly in Para State (Serra Pelada, Tapajós), Amazonas State (Madeira), Mato Grosso State (Alta Floresta), Amapá and Roraima.

Modern mining methods for gold production have rarely been applied in Brazil. Once the industry is able to modernize, it is estimated that production from registered mines will increase from 7.64 tonnes in 1984 to 30.03 tonnes in 1990 (41 percent of Brazil's total gold production). New technology is already modifying gold production. While Brazilian mining law requires garimpeiros to use manual methods, many use such equipment as front-end loaders and trucks. New machinery enables thousands of garimpeiros to form "clandestine companies" of their own, to share risk and production with their co-workers. Costs for basic mining machinery are low (about U.S. $5,000 to get started)

and local merchants, gold buyers, air taxi owners, etc., often grubstake garimpeiros in exchange for half the production.

The future trend in Brazil points to modern sophisticated exploration-mining-beneficiation technology for more gold production. In 1985 the Brazilian production from garimpos was estimated to have dropped to 60 percent of the total - a downward trend which will continue over the next decade. The Brazilian government and the gold producers have recognized that garimpeiros recover less than 35 percent of contained gold, compared to a 90-percent recovery obtained with mechanized processes. Because of their inefficiency, the garimpeiros will not mine the lower grade deposits, which in many cases are extensive. They also have been unable to go underground in any organized fashion because of their inability to use explosives. Because garimpeiros require relatively high grade alluvial ore in order to make money, they ignore ore below a cut-off grade of one gram per cubic metre, which would be highly profitable ore for a dredge to work.

To a great extent, the future level of Brazilian gold production from alluvial deposits will depend on the number of mechanized placer mine operations which go on stream in the next few years. The economics of placer mining is characterized by low capital cost and short lead time from initial exploration to production, (as little as six months). A simple washing plant and a large backhoe are required, both of which can be either land-based or on pontoons. This machinery is readily available in Brazil, with a medium-sized washing plant costing approximately U.S. $650,000.

These are very important factors for a newcomer to the Brazilian gold mining business who needs to build a cash flow rapidly. Furthermore, using statistical information available from the Brazilian Ministry of Mines and Energy concerning garimpeiro operations, exploration costs for a new company putting placer deposits into production can be kept to a minimum. Two of Brazil's fastest growing mining companies - Paranapanema and Brumadinho - are exclusively involved in alluvial mining (tin and gold) and have consistently based their production decisions on very preliminary investigations of garimpeiro operations.

Major industrial operations are the Morro Velho underground mine in Minas Gerais State with 5.6 tonnes, Tejucana dredging operations in Minas Gerais with 0.25 tonnes, Passagem Mine, Dragagem Fluvial and Jacobina Mine. The Morro Velho Mine plans to expand to a production of 10-11 tonnes per year by 1988, investing approximately U.S. $250

million. Like other Brazilian gold mining companies, the Morro Velho produces bar gold. Most mines, however, sell gold concentrates and/or gold bullion to custom smelters and refiners. A substantial amount of gold is recovered as a by-product of copper and iron ore operations.

The Aracy Mine in Bahia State, belonging to the Companhia Vale de Rio Doce (CVRD), will start as an experimental mine before major investments are made in this project. Meanwhile, Serra Pelada is responsible for approximately 20 percent of the total Brazilian gold production.

Currently there are many industrial mechanized gold mine operations being installed in Brazil and it is estimated that approximately 50 new medium-sized gold producing units (averaging 20,000 cubic metres per month of ore) were in operation by end of 1985, creating at least 50,000 new direct jobs in this sector of the mining industry.

As gold mineral exploration work in Brazil picks up, more gold discoveries are being made - the surface has not yet been scratched. If a company is really interested in gold, it definitely should be exploring in Brazil. Geologists and professional prospectors see a gold belt emerging, from the garimpeiro discoveries and from satellite imagery, that stretches east across Amazonia along a series of eroded mountains, from Rondonia in the west part of Serra Pelada to near the Atlantic coast. It is also expected that another gold belt may soon be identified north of the Amazon river.

Once industrial mechanized operations are in place, Brazil's current gold rush will become even greater in the next 5-10 years.

The Financial Side of Brazilian Gold Production

Although there is no obligation to sell gold concentrate, gold bullion or refined gold to the Central Bank (or to Caixa Economica Federal which acts as an agent of the Central Bank), the Brazilian government stimulates gold production by paying the producers for their gold, through its Central Bank, in cruzados[1] at the free market rate (black or parallel market), rather than at the official rate. This policy provides cheap gold for the Central Bank at the marginal cost of printing more cruzados.

1. According to Consolidated Gold Fields, a more stable economic environment seems to be developing in Brazil since its financial restructuring and the replacement of the cruzeiro by the new cruzado on 28 February 1986 (ed.).

Brazil's current financial problems have been beneficial to domestic gold producers. Demand is considerably up and gold, one of the most attractive investment alternatives currently available in Brazil, is a commodity that has a guaranteed market in Brazil.

Gold is instant foreign exchange in the hands of the Brazilian Central Bank. It is believed in Brazil that a rapid increase in gold production is one possible solution to the country's short-term cash bind or liquidity problems. The government will continue to encourage domestic gold production, since this is of vital importance to the future economic health of the Brazilian economy, especially now that the industrial nations have imposed barriers and quotas on some of Brazil's major exports such as steel, alcohol, and some manufactured goods. Also, the Brazilian Central Bank plans to buy gold even more aggressively than in the past - to avoid smuggling and to stimulate internal savings of individuals and financial groups - and to buy gold in cruzados at prices higher than the international quotations.

Recognizing that Brazil needs more mines, more domestic and foreign investment, and more mechanization in order to make the large quantum jump in gold production needed to increase gold production from the 63 tpy level the target of 200 tpy by 2000, the Brazilian government is also offering various fiscal and financial incentives at the state and federal level. Fiscal incentives include a depletion allowance of 20 percent per year for a 10-year period, depreciation, and income tax exemptions in the SUDAM and SUDENE regions. This great increase in production will require a huge amount of new investment (estimated to be approximately U.S. $4 billion) for the mechanization of production, either for large-scale dredging of alluvial deposits or for new underground mines for primary ore deposits.

On average, the cost of an ounce of gold produced by a medium-sized washing plant in Brazil ranges from U.S. $50 to U.S. $100 per ounce, compared to U.S. $260 - U.S. $280 an ounce for gold produced by South Africa's underground mines.

Gold sold to the Central Bank is refined at a gold smelter and refinery belonging to the federal government, Casa da Moeda do Brasil (CMB). CMB has invested U.S. $8.3 million to expand its current gold refining capacity from 40 tpy to almost 100 tpy. This move is part of an overall strategy of the Brazilian government to transform most of Brazilian gold production to convertible capital reserves, depositing abroad gold metal bars of 400 ounces (about 12 kilos). In 1984 the Brazilian government bought approximately 50 tonnes of gold. CMB has also registered

its trade mark in the London Gold Market in order to facilitate the commercialization of the Brazilian product abroad. Brazilian gold was previously refined in Casa da Moeda and rerefined again in London to be sold abroad.

Brazilian measured and indicated gold reserves have excellent liquidity and are easily negotiated. This is one of the reasons for the current gold rush. Currently there are 60 large industrial groups, 250 medium-sized groups and 8,000 small-sized groups active in the Brazilian gold sector. Among the large national and multinational companies, we should mention: Companhia Vale do Rio Doce (CVRD), Anglo American, Bozano-Simonsen, Gencon, Treasure Valley-Dunbrás, BP Minerals, Monteiro Aranha, Noranda, Eluma, Rio Tinto Zinc, Kennecott, Anaconda, Western Mining Corporation, Alcoa, Andrade Gutierrez, Brumadinho, C.R. Almeida, Rede Globo, Broken Hill, Paranapanema, CPRM, Ishikawajima, Aoki, Brascan, Ultra Group, Shell-Billiton, Unagem, Antunes Group, Degussa, Camargo Correa, South American Placers, Constram, COPELMI, Queiroz Galvão, Brasif, SAMITRI, and Auxiliar.

Brazilian Prices for Gold

Gold is sold in most markets by the troy ounce rather than by the pound or the tonne. In Brazil it is sold by the gram. The Brazilian Central Bank plays a key role in establishing domestic prices for gold. The domestic price is based on the international price (London and New York fixings) and on the parallel (free or black) exchange rate for the cruzado and the U.S. dollar: i.e. the domestic gold price = the international gold price x the free exchange rate.

The Central Bank tries to administer the domestic price of gold by buying and selling gold in the free market, as well as by buying gold from producers. Since the international gold price is established outside the country (London and New York), the volume of gold bought by the Central bank also affects the black market exchange rate for U.S. dollars in Brazil.

Alluvial gold goes through a long route, from hand-grabbing with a pick and shovel and other rudimentary mining methods to the jewelry industry and the final consumer. In the production region, the gold buyer sells to the owner of the gold store, who sells to an airplane pilot, who in turn takes the metal to São Paulo or Rio de Janeiro. There one finds centralized purchasing for powdered gold. At this point appear the commercialization firms which analyze, buy, refine, and produce gold bars.

In the case of gold produced in mines, the commercialization route is simpler. The mining company sells, without a standard quality and weight, and then the commercialization-refining firms analyze, purify and standardize the gold metal in quality and weight. Brazilian firms which commercialize gold generally keep confidential information about their customers and about their own volume of business, hiding forever the amount of gold in the hands of individuals. Although it is possible to export gold legally from Brazil, at most times this is not attractive economically. Considerable volumes of gold, however, are smuggled out of the country. Table 2 shows the gold refining and commercialization channels for key producers in Brazil in 1986.

Conclusions

Brazil's awesome geological potential is largely untapped. In its relatively short mining history, Brazil has a reasonably well developed mining infrastructure. Companies find all the equipment necessary for exploration and that for production is manufactured inexpensively and efficiently. There is, however, a shortage of experienced geologists and engineers for the development of gold and tin placer deposits. Unskilled labour is cheap and abundant in Brazil, costing approximately U.S. $60.00 per month - about one-sixth the cost of black labour now working in South African underground gold mines.

The Brazilian mining industry contributes approximately two percent of Gross National Product and is the sector of the economy that had the fastest growth rate in recent years. Decreases in gold production in South Africa, Canada, United States and USSR from historical levels will be made up by the increase in production in Brazil in the next few years. There is no question that the gold fever has reached Brazil and that in the years to come we will see here in Brazil one of history's biggest gold rushes.

Table 2

GOLD REFINING AND COMMERCIALIZATION CHANNELS FOR KEY PRODUCERS IN BRAZIL - 1986

Mining Company	Refining	Commercialization
Large Producers:		
Morro Velho	Morro Velho	Morro Velho and Central Bank
CVRD	Casa da Moeda	Central Bank
Medium- and Small-Sized Producers:		
Caraiba	Caraiba	Central Bank
Paranapanema	Ourinvest	Ourinvest
CMP	Ourinvest	Ourinvest
CNM/Dunbras	Most probably Casa da Moeda	Central Bank
RTZ/Autram	Most probably Casa da Moeda	Central Bank
Santa Martha (Cabacal)	Caraiba	Central Bank

Source: Claudio Margueron Consultonia Limitada.

Notes:

1. Ourinvest does refining and commercialization for some primary producers such as Paranapanema. However it refines and commercializes mostly secondary metals.

2. Goldmine, Newgold and most of the other Fundidoras acquire their gold from garimpos. Goldmine has 38 purchase offices in garimpos. They are more aggressively trying to buy from mining companies.

3. Degussa belongs to a large international German-based conglomerate active in precious metals. Reserva and Degussa seem to have shareholders in common. Degussa may also have an equity participation in CMP-Companhia Mineracao e Participacoes.

DIGEST OF DISCUSSIONS

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Introduction

Long-term prospects for gold mining were considered by participants to be essentially a function of the price for gold - a factor which was considered more significant than other influences such as technology, endowment, or the role of government. Discovering new deposits and putting them into production can take several years or more. Additional years are needed to recover costs and produce a return on investment. Consequently, long-term forecasts of gold prices are an essential ingredient of investment decisions in gold mining. Long-term forecasts, however, have been unreliable in the past, and analysts continue to disagree widely on the future behaviour of gold prices and on some of the unknowns and uncertainties that make forecasting a precarious art.

Two basic factors underlying price changes are supply and demand. Not only are forecasts difficult in both these areas, but there are problems of measurement in the existing and historical levels. Further complicating the relationships that affect price are the influence of exchange rate fluctuations, advances in technology, links between cost and price, and government policies that affect investment decisions, supply, and demand.

Participants discussed all the above factors, and the difficulties of unravelling the complex relationships that influence gold prices, production levels and investment in gold mining. Observations were made on areas in need of further study, and on ways to improve the industry's prospects.

Price

The price of gold was of central interest to all those involved in the industry, and the potential effects of both new and secondary supply on price. "About 100,000 tonnes of gold has been mined over history," noted one participant, "it's all out there and could start to come back into the market if prices get high enough." This gave support to Gerry Anders' forecast of low future gold prices, and to another prediction that the price was likely to fall below

$3001, both of which remained unchallenged.

What was challenged was how the price of gold is determined. Participants were not in agreement on the influence of supply and demand on the price of gold. While some argued that the price of gold is an independent variable not determined by demand or supply, others supported the more conventional view that the price is determined at the margin by the size of supply/demand imbalances. In 1986, for example, the 2.8 million ounces of gold that was left for investors, after purchases of coins, jewelry and other forms of consumption, resulted in a small demand response but a significant increase in price. Perhaps, it was suggested, we do not even understand modern supply/demand relationships, supply/demand concepts are derived from the 18th century world of local agricultural markets, where production cycles are short and everything is consumed. Metals, however, do not fit this economic model.

Another view regarding the price supply/demand relationship is that demand determines price in the short run, while in the long run price is determined by supply and in fact reflects the cost of production. This latter interpretation was disputed by some, with evidence offered to indicate that, in fact, costs are more likely to track prices than the reverse. Again, however, this may be a short-term effect rather than a long-term relationship.

The measurement of historical and current gold prices is complicated by such considerations as the fact that some countries (India and Indonesia, for example) have a domestic price that is totally independent of the world price. Furthermore, exchange rate fluctuations complicate comparisons between countries and the evaluation of trendsover time. It was noted that domestic price differentials produce a strong incentive for smuggling to areas of highest real prices, and in the process complicate the task of measuring gold production, stocks, and flows. Some developing countries, explained an analyst, turn a blind eye or even encourage the smuggling of gold across their borders, when the black market price and fixed domestic price for gold diverge too much.

A further complication to the question of gold pricing is the fact that, as stated in discussion of Timothy Green's paper: "The paper or futures market is not well informed. It only reacts after changes have taken place in the physical market. Hence prices can get out of line with actual demand for several months."

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1. Money units used throughout this discussion are defined as constant 1987 U.S. dollars, except where reference is to papers which have adopted a different base year.

Participants expressed the wish to know more about gold pricing, supply and demand forces, and to be able to predict future trends. An idea of what price trends would be in ten years would be of use to companies just starting development of gold deposits, while those on the verge of production would need to understand where the price will be going in three or four years. It was suggested that, although we cannot project the gold price for the long-term future because we cannot project the underlying economic conditions, we could still create a tool of practical value if we were better able to use our knowledge and experience of the analytical framework of gold markets, of how the various supply and demand elements behave and relate. We would then be able to consider a range of future economic scenarios and to identify a range of possible long-term implications for gold prices.

Some argued with this approach, pointing out that if we endeavour to forecast even macro-economic trends, we need the ability to forecast the various economic elements and policies of governments around the world that interact so complexly in determining those trends. This begged the following questions: can we really forecast these elements, can we determine if governments are being agents or victims of change? On the other hand, commented an analyst, there are good forecasters who could help foresee future trends, but these services are extremely expensive and out of the reach of the average company.

An alternative to price forecasting was suggested by one participant: Why not forecast cutoff grades or pay limits rather than trying to forecast price and cost? One response came in the form of another question: From what base do you start? If from today's base, major assumptions still have to be made regarding the price of gold. Another suggested alternative was to look at the cost side, to determine the minimum price of gold necessary to justify mine development.

Many other uncertainties which participants would like to see resolved were raised regarding gold pricing. These include:

- the sensitivity of gold price to increasing new mine supply;
- the main ingredients of central banks' decisions to buy or sell;
- the power of investors (in coin and bullion) in the overall market in establishing price;
- the effect of continued production on the part of lowest-cost producers (eg. at $200/ounce);

- the actual amount and sources: how much is to come from centrally planned economies or secondary sources; and how much is there, really, in the world (is some gold being double counted? e.g. the gold held in accounts and the gold backing paper figures but held elsewhere; is smuggled gold being fully accounted for?);
- the future demand, e.g. will Japan, which in 1986 bought 9.4 million ounces, the equivalent of the entire South African production, continue to be a major market? If not, what could replace that market?
- will the USA sell its gold reserves and thus force a drop in price? How will attitudes twoards gold change with new people in the U.S. Treasury?[2]

One observation brought forward by an industry analyst was that it is actually the perception of price in the light of currency variations that is more important than the real price. The real price of gold in 1974-75, for example, was lower than the price in 1985. In spite of this, the 1974-75 selling price turned off demand, while demand was turned on in 1985. This example was further expanded by one participant, who pointed out that in 1985, when the price of gold came down under $300, gold buyers in the Middle and Far East felt gold was cheap, and the physical demand then became enormous. At that time, however, the dollar and the yen were both strong. Thus, in a sense, gold was not "cheap" in Japan. As Martin Murenbeeld concluded in his paper: "The price of gold is not the same for everyone."

Exchange Rates

"Exchange rate policy is a very key element in any strategy which will expand exports and would reduce imports," stated one participant. "Let me also say," he continued, "exchange rate policy fits in with other policies such as carat adjustments, taxation policy, reducing barriers to entry, opening up economies." In linking exchange rates to gold, he commented that investment decisions on the supply side, in South Africa for example, depend on the price of

2. For example, U.S. Treasury Secretary James Baker, while speaking at an International Monetary Fund meeting held in October 1987, proposed the reintroduction of a monetary standard based on a basket of commodities, including gold.

gold and on the cost of the rand. The same is true for gold in Australia, and for copper in Chile. On the demand side, "the price of gold can look very different in yen to the Japanese consumer." The industry therefore must take into account more that just the U.S. dollar price of gold. Changes in exchange rates - both devaluation and upvaluation - were seen to affect the gold industry, at times in rather indirect ways. For example, devaluation significantly reduces the standard of living which, in turn, creates wage pressures by stimulating employees to try to "catch up". In South Africa, rand devaluation leads to social unrest, which in turn has an impact on production. In times of massive devaluation in Indonesia, gold stops pouring out of the country. And chronic devaluation, concluded a financial consultant, is usually combined with excessive exchange rate controls.

Hedging

One strategy in response to exchange rate effects is hedging, or pre-pricing. Hedging, one participant explained, originally referred to protecting the middleman (who historically was the miller), leaving the risk for the farmer. In the gold industry, stated another, it is the refiner who is the hedger. What the gold producers are doing, however, is more correctly referred to as pre-pricing, i.e. seeking protection by selling forward. Whether referred to as hedging, pre-pricing, or selling forward, participants awarded the strategy a lot of attention.

In Canada and the USA, it was pointed out, international mining groups can sell their product directly (as compared to South Africa where gold sales are government controlled) and can therefore enter into futures arrangements. Even though they may misjudge the market, gold producers do have the opportunity to sell forward, sometimes locking in a higher price. In response to a question concerning how much is actually sold, an industry representative answered that his company sells no more than 50 percent forward, but that he also knows of two companies which sell 100 percent forward. This, he feels, is dangerous. Some companies sell a fixed percentage forward, but over time that strategy is no different than not hedging at all. Some companies will hedge when price is very high, others when price is low (i.e. when the price falls, you try to sell forward at a higher price to extend the life of the mine and avoid the decision to close).

The purpose of hedging was given as twofold: first to maximize price, and second to reduce uncertainty. Reducing uncertainty may be useful, even if a company finds it is selling its product at lower-than-market prices, since in this way it may be able to stabilize operations, guarantee employment, or permit development. "It's crazy to take spot prices," stated a financial analyst who offered the following comparison in explanation: it would be equivalent to a railroad company that built a number of cars and, on the day they are completed asked around: "What's the going price for railroad cars today?"

The question was asked whether there are any costs to hedging. "The true hedger," was one answer, "is the guy who buys his concentrates today and sells them forward at that same price: he doesn't lose anything." Since hedgers hold gold as a high-liquidity short-term investment, there are no real costs attributed to hedging. The forward market is determined to be an unbiased estimate of the future; forward market interest rates differentials are an estimate of the future expectations.

The Demand for Gold

"Because gold mining and production are expanding," stated an industry representative, "we need an expanding market to help maintain the price. " The question remained, should this market be based on monetary or commodity demand. In his paper, Gerry Anders concluded that gold is acting more and more like other metals, like a commodity. Also, like other metals, gold faces threats from substitution. In discussion following Anders' paper, some participants agreed with the fact that gold, in parallel with forecasts for non-gold metals, will experience a long-term downward trend. "We'll have to rely," commented one analyst, "on the vanity factor to counteract this trend." Others felt that gold is returning to a position as a monetary vehicle and thus is not just a commodity like other metals. This contrasts both with Anders' view and with the statement made by Timothy Green in his paper: "Given that the dollar's official link with gold was formally snapped in 1971, we must regard gold's future essentially as a commodity, not as a monetary metal." But, another participant concluded, despite the fact that gold is no longer monetary, many are still behaving as though it is monetary (for example, governments holding gold coin).

The specific areas of demand and potential demand growth discussed included the jewelry and coin market, and industrial use, especially dental.

The Jewelry Market

The demand for gold for jewelry was found to be one of the reasons explaining gold's unique behaviour. Commenting on Anders' message that gold is going to behave more and more like non-gold metals, one participant noted: "Both Jeff Nichols and Tim Green have pointed out to us that 50 percent and sometimes more of annual gold production goes into jewelry, and that most jewelry represents a hoarding function. This means a substantial amount of gold does not have the character of industrial metal, so that gold over all may still not conform closely to the trading pattern of industrial metals."

The importance of jewelry in the demand for gold was clearly recognized. One participant compared jewelry to a safety net for gold demand and recommended that the industry should encourage the raising of this net. Another participant, however, had severe reservations about trying to stimulate high margin jewelry markets. He felt it would be better for the industry to try small bar and other markets. The price of gold, in turn, plays an important role in demand. Jewelry demand goes down as gold prices go up, it was observed, in both developed and developing countries, although the responses are not identical.

The market for jewelry was recognized as being clearly divided into these two main areas: developed and developing countries. The comment was made that perhaps sales in the former could be increased by adopting some of the developing countries' practice regarding gold. In particular, Green reminded participants, that in developing country markets, gold jewelry is purchased on very low markups of only 10 to 20 percent over the gold price of the day, compared to the 300 to 400 percent markups common in Europe and North America. With such high markups, North American jewelry prices do not respond to changes in gold prices as readily as they do in developing countries. "The high markup in North America on gold turns off a lot of buyers," stated one participant. "The only area showing sustained growth in the jewelry market," he continued, "is the Asian community in Canada (Toronto, Calgary and Vancouver), where there is substantial increased offtake of high-carat low-markup jewelry. It's the same in Britain." One suggestion was that the industry should perhaps integrate downstream into the jewelry business. However, another participant argued that the industry must use its influence, but not try to take over the jewelry business.

The Coin Market

The coin market, like the jewelry market, was seen to be an area through which the demand for gold could be increased. One of the small-group discussions concentrated on coin demand concluding that:

- the Krugerrand is passe in the Western Bloc (where its sales have dropped sharply following the imposition of sanctions);
- the Gold Maple Leaf has enjoyed a period of popularity;
- the market will become more competitive with the entry of new gold coins such as the U.S. Eagle, the Australian Nugget, and the Japanese Hirohito;
- the gold coin is most popular with gold bullion investors or people who believe in gold;
- the political climate of the country of origin affects the liquidity of the coin;
- about 9 percent of mine production goes towards the production of coins, and that figure has been decreasing for the past two years.

Four major uses for gold bullion coins were presented:

- investment;
- security;
- a monetary unit (particularly in the Far East, especially since there are many people in Hong Kong purchasing gold coins as an "entry ticket" into North America, in anticipation of the return of Hong Kong to Chinese rule in 1997);
- jewelry, gifts, collectibles.

There were found to be both positive and negative factors influencing coin demand. Among the positive factors identified were the coin's appeal to patriotism, international liquidity, worldwide distribution, portability, anonymity, its acceptability as legal tender, and the availability of fractional sizes. Advertising and promotion and the existence of secondary markets also act to encourage demand. Working either as positive or negative factors were political factors, national origin, purity versus durability, exchange rates, the price of gold, and the use of national gold. Definitely negative factors were sales tax and markup or premium.

A marketing strategy to increase the demand for gold coins was also suggested. Not in any order of priority are the following suggestions:

- develop the market for coins as jewelry. For example, there is a substantial market for class rings, which represents as many as 100,000 units per year, through which the use of the 1/10 oz coin could be promoted as jewelry rather than investment;
- lobby for tax reform to exempt coins from sales tax. In many areas, coins are exempted from luxury tax, but this is not the case in Ontario. In the USA, no tax is payable on coin sales if the coins are held on account rather than delivered;
- establish coins as a form of settlement for some kinds of investment transactions (e.g. dividend payment) by lobbying for a tax incentive for the shareholder;
- establish eligibility for coins in retirement investment plans and other tax shelters, as well as in general investment portfolios;
- encourage the entry of new coins. The additional advertising and promotion benefits the entire industry;
- Develop a greater use of gold coins in corporate incentive programs;
- encourage the development of patriotic buying in originating countries by advertising and promotion.

It was generally agreed by workshop participants that the arrival of new gold coins on the market is a welcome development which capitalizes on gold's long-term attractiveness for hoarding. Coin buyers hoard, said one industry executive, and thus coin sales foster long-term investment since most purchases represent new sales. This is why South Africa developed its Krugerrand - an initiative which opened up a whole new market by making gold available at a low premium to the ordinary person in the street.

The Use of Gold by the Dental Industry

Gold use by the dental industry is facing threats from two sources. One is the arrival on the market of replacements for high carat gold used in the dental industry, i.e. ceramics and lower percentage gold alloys. Another threat is the reticence of government health insurance programs to cover the cost of gold dental work.

The following example was presented to demonstrate the importance of government policies concerning health insurance programs for the use of dental gold. During the mid-1970s Sweden allowed all dental gold work to be paid for on social security. During that period, dental use of gold doubled in one year. Similarly in Germany in 1975-76, three

years after similar legislation came in, gold use in dentistry went from 12 tonnes to 28 tonnes per year - the biggest single change in gold demand ever seen in the dental sector. Once the German government tightened up regulations in this area, dental demand dropped again to 14 tonnes per year. Predictions were that future dental demand for the world will be flat, holding at best at about 50 tonnes per year.

Supply and Costs

The amount of future new supplies of gold supplied to the market, whether from existing mines or from new discoveries, came up often in discussion. This amount was not seen as a fixed number of tonnes but rather as a figure which changes to accommodate changing gold prices. With each rise in the price of gold, existing mines are encouraged to extract lower-grade ore, and the incentive for exploration for new mines is increased. Even if prices fall to $250/oz, stated an industry consultant, gold supply will not be cut back significantly. "There is an enormous amount of fat in the gold industry," he said. Soon to be added to present producing regions as a source of supply, according to one industry representative, is the entire Pacific Rim - an area potentially rich in gold just waiting for the right political and economic conditions. Even with good exploration skills, technology, and endowment, however, the gold price, as well as exchange rates, government policies, and management attitudes can have serious effects on supply.

"Since 1980, because of economic circumstances, there has been a massive concentration, quite unprecedented at any point in recent history, of research efforts into gold exploration techniques in all directions - mining, geology, government agencies, universities, mining companies," stated a professor in geological sciences, in agreement with Woodall's statement that gold production is going to increase. He continued to say, however, that gold deposits are in general very diverse and difficult to evaluate and to develop successfully, and the risk of technical failure with gold deposits is far higher than with base metal deposits, in all circumstances. Also, in the gold industry, an optimum discovery rate is much more dependent on exploration skill and management attitudes. Being average, he stressed, is not sufficient; only the very successful succeed in recovering a rate of return.

Even though the technological advances in the last five or six years in gold exploration have been enormous and are beginning to have a very great impact on gold production, it

is still important to keep both discovery and production costs to a minimum. As one participant pointed out "you don't need to have a blue chip gold mine to make money. What you need is a well designed, lean operation." In other words, he suggested, many mines that have been shut down due to low tonnages and low grade ore could have remained open with proper management. When deposits start to fade, the first thing management does is lay off the geologists, complained one geologist, although the most economic time to find gold is before the mine closes and the community dies, and the most economical place to find gold is at the existing minesite.

In his role as discussant to Jim Fisher's paper, "Mine Gold Supply to the Year 2000", Herman Enzer, took the opportunity to provide some additional data on gold availability and break-even costs from a U.S. Bureau of Mines Study.[3] His comments and documentation are quoted in detail below.

> I would like to provide a vertical dimension to table 6, "Western World Gold Cost Distribution" (in Jim Fisher's paper), based on work that we've just published the Bureau of Mines. We have a so-called minerals availability system which covers approximately 2,500 of the world's largest deposits and active mines for about 30 minerals. Our recent report on gold estimated its availability based on demonstrated resources, not reserves, for 111 of the largest mines and deposits in the western world (excluding Russia and China). These 111 deposits include over 90 percent of primary gold available and over 80 percent of primary plus by-product gold. I would like to give a few numbers based on the 111 mines.
>
> According to what we estimate, we have South Africa with 22,268 tonnes, then the USA with 1,000 tonnes, Canada with 1,138, and Brazil with 305 tonnes, and other countries - all of them adding to a total of 25,471 tonnes.[4] This is availability, not supply, as of the end of 1984.

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3. P.R. Thomas, E.H. Boyle, Jr., "Gold Availability - World: A Minerals Availability Appraisal", Bureau of Mines Information Circular/1986, IC-9070.
4. See table 1.

Table 1

TOTAL DEMONSTRATED PRIMARY GOLD RESOURCES IN 111 SELECTED PROPERTIES IN MARKET ECONOMY COUNTRIES AS OF JANUARY 1984

Country	Total Contained Gold (tonnes)	Total Recoverable Gold (tonnes)	Total Recoverable Gold (% of total)
South Africa	23,576	22,270	87
United States[a]	1,257	1,002	4
Canada[a]	1,194	1,138	4.5
Brazil	327	305	1
Ghana	227	187	1
Australia	208	199	1
Philippines	127	109	1
Zimbabwe	115	93	1
Chile	75	62	1
Bolivia and Columbia	31	25	1
Taiwan	16	12	1
Total	27,153	25,473	100

Source: P.R. Thomas, E.H. Boyle, Jr., "Gold Availability - World: A Minerals Availability Appraisal", Bureau of Mines Information Circular/1986, IC-9070, p. 7.

[a] Estimates differ from totals give in country sections owing to the exclusion of certain nonproducing properties.

Note: data may not add to totals shown because of independent rounding.

The cost availability curve looks like the conventional supply curve an economist would plot. But the real supply curve for gold is probably vertical or perhaps negatively sloped. Table 2 shows, for example, that you have 14 mines out of the 111 (or 22 per cent) which can supply 5,738 tonnes of gold at a break-even cost of $200 or less. South Africa is by far the largest producer representing 87 percent of the total available gold. Again looking down the table, 70 percent of the total gold is recoverable at a cost of $300 or less. This gold is available from just 46 operations, 23 of which - accounting for 90 percent of the gold - are in South Africa. The next line in the table shows that 82 percent of the total is available at a cost of $400 or less, and again South Africa accounts for about 90 percent of the gold in this category.

Table 2

DISTRIBUTION OF TOTAL RECOVERABLE GOLD BY COST LEVEL AND COUNTRY

Break-Even Cost or Price Level[a]	Number of Operations (cumulative)	Total Recoverable Gold, tonnes (cumulative)	Cumulative Percent of Total Availability	Countries Within Indicated Range, Ranked by Amount of Recoverable Gold
$200 or less	14	5,739	22	S.A., Canada, Brazil, USA, Dominican Republic
$300 or less	46	17,928	70	S.A., Canada, USA, Australia, Philippines, Zimbabwe, Chile, Bolivia
$400 or less	71	20,764	83	S.A., Canada, USA, Australia, Brazil, Zimbabwe, Columbia
$500 or less	96	24,046	94	S.A., Canada, USA, Phillippines, Australia, Zimbabwe
$600 or less	105	25,249	99	S.A., Zimbabwe, Canada, USA
$700 or less	107	25,271	99	Canada, Zimbabwe
Over $700	111	25,473	100	Ghana, Taiwan

Source: Thomas et al., "Gold Availability."

[a] The break-even cost or price level is that point where long-run total production cost per ounce = required price per ounce to obtain a 0-pct discounted cash flow rate of return.

The break-even cost per ounce results from the discounted cash flow analysis where you include all the costs but there is no rate of return, i.e. a zero rate of return calculation. If you do the same for a 10, 15 or 20 per cent rate of return, then obviously the numbers go down quite significantly in some cases. So this is the gold (the total recoverable gold) that can be made available at a particular moment.

Forecasts

Forecasts for gold supply were found to vary depending on the source. For example, it was pointed out that Danie Krige's estimates of 700-825 tonnes for South African production in the year 2000 are much higher than the Brook Hunt figures of 590 tonnes presented by Fisher, since the former include estimates of new production. One participant found Fisher's forecasts to be pessimistic, pointing out that higher exploration efforts and better techniques may provide better results in the future. An industry analyst was also more optimistic. He feels the "terrific activity" in the USA - as evidenced by the increase of gold mined per year from 30 to 150 tonnes in one decade - will continue, and predicts the country will be mining 160 tonnes of gold by 1990. Another participant warned that endowment characteristics of unexplored areas, and possible government involvement in countries such as Brazil, which is showing significant potential for new gold discoveries, must also be considered in any forecasts.

Potential Oversupply

The potential of an oversupply of gold and its effect on the price of gold was a concern which received special attention. "Oversupply," defined a small-group discussion on the topic, is the "amount of supply that will push the average price down to the point that it becomes uncomfortable for operating mines." A monetary figure for that point was said to be over $300 as a comfortable price, and below $250 as an area of discomfort.

Western World supply excluding South Africa, it was predicted, will increase at gold prices over $300 per ounce at the rate of about 200 tonnes per year every five years, up to the year 2000. South African supply will remain constant to the year 2000, and may decline thereafter. And the

effect of this increasing supply on the price of gold? Up to 1990, the market can probably accommodate prices over $300. But between 1990 and 2000, the appetites of investors will or may become satisfied if they are left to take up the surplus. "Price," underlined the group, "is likely to fall below $300."

Among the suggested actions which could be taken to stem the forecast drop in price were the following:

- the artificial stimulation of gold exploration by some governments should cease;

- more attention should be give to the stimulation of jewelry and coin sales, thus reducing the amount of new gold production for investor take-off;

- high-cost mines should not receive artificial support enabling them to stay in business and continue production.

The Role of Government

Government, it was agreed, has a major (and mostly negative) effect on the gold industry. "Attitudes about gold," stated one participant, "have shifted over hundreds of years. Politicians don't understand the implications of gold transactions." The demand for gold, i.e. the development of a particular market, has a lot to do with the tax environment.

In developing countries, commented one participant, governments are turning more towards activities such as gold exploration and production which have traditionally been dealt with by the private sector. In Brazil, for example, the government is moving into refining and has the best facilities in the country. The question was asked if other governments were following suit. In the West, answered an analyst, there is a greater willingness to leave the exploitation of gold resources to the private sector.

Another form of government involvement which was identified as a negative influence is South Africa's role in marketing gold. The South African government buys all the gold that is mined, keeping the industry very remote from downstream activities. In Canada and Australia, commented an analyst, producers at least have the chance to integrate forward and take advantage of future market opportunities. The industry's knowledge of forward markets, however, complained one participant, is incredibly limited.

One conclusion reached was that gold mining should not be taxed (as has been the case in Australia). Any profits should go to investors and be taxed at that point. In general, government policies that impose costs on the industry were recognized as having the potential to smother possible future creation of wealth by cutting the rate of return to the point where exploration will fall below the level necessary to maintain reserves and production.

Flow-Through Shares

The existence of inequities in the ability to write off exploration costs against taxable income was cited as a major concern in the industry. Flow-through shares are a useful fiscal tool for reducing this inequity by giving firms with no taxable income a means of taking advantage of write-offs. The flow-through share results presented by Basil Kalymon generated much discussion. It was noted that the effect on the long-term industry is still unclear. How much exploration, for example, would have taken place anyway, even without the program, and how much can be directly attributed to flow-through?

Problems associated with flow-through shares were also discussed. For example, in producing companies with new flow-through issues, the old shareholders who also bear part of the exploration risk for projects funded by the new issue did not receive the tax relief provided to the new shareholders. At the same time, the ongoing operations shelter the risk of the new shareholders, who get all the tax benefits related to the new issues.

It was suggested that flow-through be extended to cover development costs. Although the idea is being discussed, it is doubtful that the Finance Department will approve it. Another point raised was that the flow-through concept was brought in when base metal companies were in difficulty. The result, however, was not assistance to base metal mining or an increase in base metal exploration, but rather the diversification of many of these companies into gold mining.

In Conclusion

As the workshop closed, the single, most important, unanimous view of the participants was that there will be an oversupply of gold in the 1990s. This was understood to mean that the average price of gold in the 1990s will be held down, most likely in the range of $250 to $350 per ounce.

Higher prices can be expected only if the larger gold-producing companies and countries are successful in promoting growth in gold demand, particularly in the areas of coinage and jewelry. In the meantime, the industry is entering a new dimension in gold mining, commented one participant, where $300 per ounce should be considered a good price. In fact, in the Western world many producers could live with prices above $200 and, in the developing world, prices above $150.

It is vital for the industry, participants agreed, to develop a management enthusiastically committed to keeping costs down, encouraging demand, and continuing exploration, especially around existing mines. Beyond this, management should also exert a positive influence on government policies. "The big question is," noted one participant, "will the tremendous cost-cutting gains made by science and technology in the last five years be complemented by constructive and forward-looking government policies and management activities?"

CONCLUDING OVERVIEW

Keith Buck

The papers presented at the Centre for Resource Studies workshop are "Long-Term Prospects for Gold Mining" were a productive combination of international and national dimensions.

The international environment was set for us by Jeff Nichols in "A Gold Market Overview: Trends in Supply and Demand". The gold mining industry in North America, Australia, Brazil - and in virtually every country with exploitable resources - has been alive with exploration, the development of new mines and the expansion of existing ones, and ultimately with increasing production. This activity is due largely to the substantial increase in the average prevailing price for gold between the past decade and the 1980s, as well as to improvements in the art and science of mining that allow for the profitable exploitation of lower grade ores. An exception to this activity is South Africa, where mining practices, along with the depletion of higher grade deposits, have moved the industry to lower and lower ore grades. Moreover, growing worker unrest has effected South Africa's total gold output. These points are all picked up and enlarged on by other papers in these proceedings.

Other points discussed by Nichols include some divergent trends. For example, countering the trend of increased mine production is a noticeable shrinkage in secondary supply from old industrial scrap and recycled jewelry. This secondary supply has diminished gradually in the past few years as a consequence of lower prices and the depletion of existing reservoirs of scrappable material. Highlighted in the Nichols overview are the large 1985 and expected 1986 sales from Communist Bloc countries, due principally to the Soviet Union's need for foreign exchange earnings to replace those lost because of lower world petroleum prices and production problems in Soviet oil fields.

On the demand side, Nichols notes that the central banks as a group began buying gold again last year and are again present as buyers this year. The uncertain factor on the demand side is that of investor demand, down from the highs of previous years. The mildly bullish nature of supply/demand forces for gold this year is strengthened by plans of several countries - Japan, the

USA, Australia and Brazil, for example - to introduce and market new gold coins.

Nichols concludes with an excellent summary of the main points affecting supply and demand this year - points which have applicability for the coming years. Although Nichols, as a gold analyst, admittedly considered future trends in supply and demand in a very short term context, he does feel that the short-term situation is leading to longer term issues. These are, for example:

- mine production in South Africa relative to other supply sources
- the future of Soviet gold sales
- the level of future secondary gold supply
- the demand side of gold used for industry, dentistry and jewelry
- Japan as a big factor in industrial demand
- will the central banks buy or sell?
- the gold supply for the USA coin program, implications for world market price

During the discussion of the Nichols overview, Brian Mackenzie asked the following:

- What are the interrelationships in changes in gold supply and what is the role of price on these changes?

- What is the role of central bank gold reserves in both the developed and developing world? What influences central bank decisions?

Mackenzie remarked in conclusion that a market force to be considered is the effect of long-term economic cycles, as distinct from short-term ones.

Further comment regarding the demand side was made by Timothy Green in "The Demand for Gold". Green stresses that there has been a fundamental shift in the character of the demand for gold over the last twenty to thirty years, from its role as a monetary metal, where the prime use was for gold coins and government gold reserves, to its role as a commodity. By the mid-1960s, it was the private sector that was consistently the major purchaser. In Green's view, we must now regard gold as a commodity, not as a monetary metal - albeit a commodity with special attraction for the investor. This is a new role for gold, unprecedented in its long history.

Green also stresses the high degree of price sensitivity surrounding much of the physical demand for gold as a

commodity. This price sensitivity is particularly noticeable in what the Swiss used to call the "traditional hoarding areas" of the Middle East, India, and South-East Asia. In these developing countries, where gold hoarding and exchange at marriages is woven into the social fabric, gold jewelry really ought to be termed "investment" jewelry, as opposed to the use of gold as decorative jewelry in developed countries. The swift switch from heavy buying to heavy selling resulting from price fluctuations in developing countries is a phenomenon only of the last twelve years. In Green's view, this has lead to extraordinary variations in demand, and a phenomenon which has a crucial effect on price development. Indeed, any understanding of the long-term price potential for demand can only begin with the realization of how volatile demand is. In the new era of gold since its monetary use declined, jewelry has become the absolute cornerstone of the market, year in and year out.

It is from this point that Green proposes that the mining industry must give consideration as to how jewelry demand can be maintained and expanded. He views this as a safety net or cushion for price declines, but not as a catalyst for increasing prices.

Neither the investor/speculator nor the central banks can be counted on as reliable cornerstones of the gold market; the future of gold lies in its use as a commodity with special appeal to private investors. Indeed, the long-term future of the metal is really in the hands of the physical users around the world - whether they give it to their daughters in marriage or tuck it under their bed!

Jim Fisher in "Mine Gold Supply to the Year 2000" emphasizes the fact that the continued impetus from exploration and the perceived profitability of gold mining have pushed up mine supply from the Western World outside South Africa at the extraordinary rate of over 14 percent per annum for the five years to 1985. As for South Africa, it is his view that if new deposits are to be found in the future, they are likely to be deep, possibly badly faulted and relatively low grade, at or below the current production yield of 6.4 g/t. He points out that the maturing nature of the South African gold mines is illustrated by the rapid grade decline over the past fifteen years.

Metal price, however, will affect production from existing mines and, in this context, it is not the dollar price that is important but rather the rand gold price and its relationship to costs in South Africa.

Fisher states that for every year since 1979, over 90 percent of gold production in the Western World has shown

an operating profit, and, from the data shown in his paper, he deduces that the gold price would have to fall below $250 per troy oz (in 1985 dollars), before it had any significant effect on primary gold production.

In a section dealing with individual countries, Fisher presents expectations consistent with a gold price in the range of $350 - $400/oz in 1986 money terms. At such prices, he believes that the current high exploration momentum will be maintained as the gold industry continues to show significantly better profitability than any other metal.

For the year 2000, Fisher forecasts a total world gold production of 2,000 tonnes. He believes, however, that in three principal countries - USA, Canada and Australia - the high rate of exploration has probably reached the point of diminishing returns and that future growth will prove more difficult. Elsewhere, higher production may well run into political/social/economic limitations, as in the Philippines, Africa and much of Latin America. Throughout, the influence of the metal price will be paramount. In South Africa, the stimulus given to gold mining by the unprecedented rand price for the metal will certainly prolong the life of the industry. Leaving present political considerations beyond the year 2000 aside, ore reserve limitations must lead to a continuing decline in the country's gold production, under any political or metal price scenario. Even by 1990, aggregate production from other Western World producers is likely to exceed that of South Africa for the first time since 1953. Contrasting with the decreasing importance of South African supply in the gold market, the economic forces in the Eastern Bloc seem certain to promote a steady increase in production, to the extent that, at some point early in the next century, the USSR will succeed South Africa as the world's largest gold producer.

In South Africa, production from gold mines will be affected by three developments:

1. Political unrest spilling over into major stoppages or curtailment of operations.

2. Rapid escalation of costs, for labour, imports and spares, the latter two arising out of sanctions.

3. Loss of skilled technical labour, as South African staff emigrate and immigration from abroad dries up.

In the long term, Fisher believes that it is the last development that the mining companies will find to be most intractable.

In the discussion following Fisher's paper, Herman Enzer presented a table arising out of United States Bureau of Mines studies of 111 operating gold mines throughout the Western World as of December 1985: 22 percent would break even at a cost of $200 U.S. dollars/oz, 70 percent at $300 or less, 83 percent at $400 or less, and 94 percent at $500 or less.

Martin Murenbeeld in his paper "Exchange Rates: Factors wich Affect Them and Their Impact on Gold", vividly demonstrated his theme that exchange rates are important to the metal. Indeed, one might go even further to argue that, in the present environment of exchange rate movement, exchange rates are vital to gold on an individual country basis.

Hence, to understand the forces at work on the gold price, one must have some understanding of currency values. Some of the most basic decisions about gold - whether to mine it or how to sell it - are dependent upon the gold price. And, in turn, the gold price is part of a function of the currency in which those decisions are made.

In presenting his theme, Murenbeeld discusses the relationship of three specific currencies - the U.S. dollar, the Canadian dollar and the South African rand - to gold demand/supply considerations and gold price.

With the U.S. dollar being the most internationally acceptable medium of exchange, it is, in effect, the numéraire for gold. Not being a passive numéraire, its volatility affects gold's value in terms of U.S. dollars. Not only does the U.S. dollar play an important role in the nominal valuation of gold, but, contends Murenbeeld, there is a strong relationship between the weighted sum of a number of individual country inflation indices, all converted to U.S. dollar inflation indices.

Murenbeeld comments briefly on some of the factors affecting changes in exchange rates: the relative levels of interest rates, inflation, monetary growth rates, budget deficits, shifts in monetary policy, trade balance, capital flows, relative economic growth rates, politics, etc. And he deals at some length with the strengths and weaknesses of the concept of Purchasing Power Parity as the most durable theory of exchange rates - a theory which indicates that currency values reflect the inflationary erosion of their purchasing power.

Turning to Canada, Murenbeeld contends that his firm's multilateral purchasing power model makes clear that inflation has been a significant factor in the Canadian dollar's long decline. Another factor, and a major one over the last decade, has been the Canadian political factor.

This factor has at least three dimensions - the federal/provincial dimension, the nationalism dimension, and the made-in-Canada-policy dimension. A third variable critical to the Canadian dollar has been Canada's non-merchandise trade balance. In this connection, it is Murenbeeld's view that Canada has a serious structural problem which will keep the dollar weak for years to come. Only periodic waves of new foreign investment (as a result, for example, of high commodity prices, cheap labour, or favourable tax treatment) can interrupt this prolonged period of weakness.

Regarding the South African rand, although political factors have played a role in its decline, it is inflation arising out of a high rate of monetary growth that has had the most significant impact. The world gold price has been the second critical factor in the rand's profile. As to the political factor, Murenbeeld concludes that, although it has not been a causitive factor, it has cost the South African currency an additive deterioration of at least 15-20 cents in recent years.

In general, Murenbeeld believes that, although every currency has its own specific factors, there are two factors that one can never overlook - inflation and politics.

In discussion, John Strongman expressed the view that the most pressing problem for the developing country is debt, the ability to service this debt and that, in the latter, the exchange rate is a critical factor. Indeed, this is a problem applicable to some developed countries, such as South Africa and Australia. He expressed the view that developing countries traditionally overvalue their currencies and when massive exchange rate devaluations occur, the standard of living is affected. Attempts by the work force to recapture standard of living losses over a short time period of say six months, can result in a 30-40 percent recapture.

Recent more open government approaches to exchange rate adjustment result in a lowering of production costs. Each adjustment, however, has a declining effect due to increased inflation. And with each exchange rate adjustment, developing countries tend to increase their commodity exports which, in turn, tends to drive down world commodity prices.

Gerry Anders, in his paper "Gold Price Forecasting: Commodity Versus Monetary Perspective", deals with longer term constant dollar trends that are of interest for the purposes of corporate and governmental mineral policy development. He does not cover temporary fluctuations of interest to the trader. A premise throughout was that data on gold production, on gold movements and on gold stocks are notoriously unreliable.

In his historical treatment, Anders commences with the observation that mineral production, over the period 1840 to 1985, was responsive to major discoveries and technological innovation. Because of the limited experience with a free market price for gold, parallels had to be drawn from the experience of other metals and of the wholesale price index, leading to the construction of a metals price index and comparisons of that with those of silver and gold. The bulk of Anders' presentation constituted an analysis of the wholesale price index, the composite real metals price index and the gold price index, over the 1840 to 1985 period. An early conclusion was that the period from the end of World War II to 1970-74, which largely shaped the outlook of today's decision makers, is an anomalous period. Another conclusion was that through much of 19th century, rising gold production was not unrelated to the existence of a floor price.

The analysis also lead Anders to conclude that gold increasingly is going to share the characteristics of other metals and that the real price of gold will over the long run partake in the flat to slightly declining trend of all other metals. Over shorter periods, however, speculative movements for gold as well as for silver, will continue to be more pronounced than for other metals. The long-term patterns suggest that with respect to metals, it is not supply and demand that determine long-term price trends, but that price is an independent variable which, in turn, determines supply and demand.

In summary, Anders contends that the following three neglected factors have significant bearings on the long-term future trend of gold prices:

1. The effects of the tremendous capacity buildup as a result of 1½ centuries of guaranteed floor prices, further boasted by the 1980 speculative boom (with the bulk of production accumulated in government hands), has not yet worked through the market under a free gold price regime.

2. To the extent that gold will, in its price behaviour, increasingly approach the pattern of other metals, it will be subject to the same secular downward trending forces which all commodities must obey in the long run.

3. The mix of gold's monetary and commodity characteristics is going to change increasingly towards the latter, not denying that some of gold's monetary role

will certainly continue and that coin sales in the West may even increase significantly.

Anders' final conclusion is that there will inevitably be, in the long term, a slightly declining real price trend for gold and other metallic commodities.

In discussion, Pat MacCulloch, noting the major discontinuity which took place in 1970, asked whether pre-1970 prices can be extrapolated, whether the past can be used to forecast the future, and whether governments are agents or victims of economic change.

Roy Woodall's paper "Gold Exploration: Impact of Changing Geoscience Concepts and Technologies", is an exposé of the recent renaissance of scientific interest in gold exploration. One of the results of this renaissance has been a better understanding of epithermal systems and advances in geophysical and geochemical prospecting techniques. Indeed, the most profound changes in exploration have resulted from a better understanding of the physics and chemistry of epithermal systems, in many cases aided by the documentation of modern analogues, the geothermal systems. It is now possible to interpret field and laboratory observations in terms of temperature, pH, CO_2 activity, boiling, changes in redox potential, solution and gas transport, likely geometry and level of exposure. For example, geochemistry is an area where there have been significant advances in gold exploration technology. Geophysical exploration for gold is almost invariably indirect and serves mainly to aid surface and sub-surface mapping of lithology, structure, associated mineralization and alterational zones - the discovery of the Hishikari deposit in Japan being a prime example of the successful application of geophysical exploration techniques. Indeed, geophysics is poised to play an increasingly important role in exploration for gold, especially in poorly exposed regions or where access is difficult. Deposits in such areas will not be easy to find and, according to Woodall, it can be expected that over the next decade or so, each significant new gold discovery will cost in the order of US $30-$50 million.

Woodall describes the opportunities for new gold discoveries on some of the more geologically attractive parts of the world and then goes on to describe the exploration potential at operating mines and concludes with a list of five key factors necessary to achieve successful economic investment in "on property" mineral exploration. These factors are:

- the encouragement by mine management of the continuous scientific study of orebodies being mined and the regional environments in which the ore deposits occur
- highly motivated, well-trained geoscientists based at the mines
- adequate exploration funds
- long-term governmental support by way of supportive taxation policies

Woodall stresses the fact that the numerous recent gold discoveries throughout the world have NOT been as a result of the application of the new technology for gold exploration and discovery, developed in recent years. This being so, the application of new technology augurs well for a continued high rate of discovery in the future.

In discussion, Bob Mason stressed the diversity of tonnage/grade combinations for viable gold deposits and the low capital cost of gold mine development. He reminded us of the uncertainties of such factors as gold price, exchange rates, government policies and management attitudes - all counterbalanced by the existence of high quality exploration expertise, good mineral endowment potential, and technological advances.

Danie Krige, in his paper "Factors Affecting the Long-Term Prospects of South Africa's Gold Production", concentrates on an area critical to the well-being of the world gold industry and a subject very much before the general world public as well as before those specifically interested in gold. He provides an analysis of factors which have affected South Africa's gold production in recent decades - factors such as gold price, escalations of working and capital costs, production capacities, long-term trends in tonnages and grade of remaining virgin areas (declining), cut-off grades, taxation, etc. He considers existing mines and extensions to existing mining areas and reefs, and also new mining areas. His conclusion is that, whatever the scenario, South Africa's gold mining industry has a great potential, and will continue to make a very substantial contribution to the future world supply of gold.

In discussion, David Yudelman reminded us that the validity of any model is subject to the assumptions on which it is based, expressing appreciation for the contribution made by Krige in developing his model for the South African gold situation. He asked four questions:

- What about future labour costs in that black labour union policy includes the provision for the upgrading of skills as well as increases in general wage ratios?

- What about taxation, i.e. South Africa moving to a flat rate of taxation?

- What if government, in seeking new tax revenue, disallows the offsetting of capital expenditures against the profits from existing mines?

- How vulnerable are the mines to sabotage?

In all instances, Professor Krige provided positive and encouraging responses.

Don Cranstone, Brian Mackenzie and Michael Doggett in their paper "Long-Term Breakeven Price for Canadian Gold Supply" emphasize that, for long-term planning purposes, one doesn't really care what the price for gold will be in 1987, 1988, or 1990. The relevant gold prices are the ones which will actually prevail when the economic deposit to be discovered is in a position to sell gold - from the mid-1990s to the turn of the century and beyond. The long-term breakeven price for Canadian gold supply comprises three cost components: production costs for operating gold mines, development costs for new gold prospects, and exploration costs for the discovery and delineation of economic gold deposits - with, for the latter, taking into account the time interval between when expenditures are incurred and when the associated gold content is recovered and sold.

The analyses presented contain what to many was a startling conclusion, i.e. that the minimum gold price requirement has only been attained once before, temporarily during the 1979-88 gold price "spike". The authors feel that, despite acknowledged uncertainty in the data base employed, the results are a cause for concern. Even assuming no exploration costs, it is their conclusion that the minimum gold price requirement would still be in the range of Can $376 to Can $609 per ounce.

The authors' analyses and conclusions lead them to pose some tough general policy questions:

- What explains the very high level of gold exploration taking place in Canada at the present time?
- To what extent are short-term corporate forces and government policy inefficiencies promoting uneconomic behaviour?
- What will be the long-term consequences of this present behaviour?

Basil Kalymon in his paper on "Flow-Through Share Financing" provides an analysis of an important source of equity financing for the Canadian mining industry, a source which has only been in existence since 1983. Public debate on flow-through shares has centred around the question of their implications for the stimulation of exploration and mining activity in general as well as their utility as tax shelter vehicles for investors. Taking into account modifications which have enhanced the effectiveness and efficiency with which the funds are applied, data on annual flow-through share financing indicates that the level of equity funds raised through flow-through shares is substantial and has grown significantly since 1983. The amounts raised have not been inconsistent with the levels of exploration activity reported for the industry which has also shown sizeable growth in the years 1983-1986.

Kalymon's analysis demonstrates that both senior and junior companies are attracted to issue flow-through shares and that although the large majority of issues are below $1 million in size (about 78 percent for 1985/86), they only account for a small percentage of the issued amount (21 percent in 1985/86). It is also demonstrated that the availability of taxable income enhances the value of exploration activities to firms when they are in a taxable position, i.e. rendering the total venture profitable if undertaken by a major company with taxable income, but rendered uneconomic if undertaken by a major company in a non-taxable position. Similarly, if the exploration is unsuccessful, the taxable company enjoys a vast advantage over the company with no taxable income.

If the intent of the existing tax structure is to maintain neutrality across alternative organizations considering the mining venture, then clearly the availability or lack of taxable income plays a non-neutral role. From the point of view of societal efficiency, the project would NOT be undertaken by junior mining companies or any firms in a non-taxable position, to the detriment of investment levels in the industry as a whole.

Kalymon concludes that flow-through shares reduce but do not fully eliminate the tax advantage for undertaking mining exploration ventures within non-taxable ("junior") companies as compared to investment through taxable "senior" companies. Furthermore, the risk exposure of the investor is substantially different with "junior" flow-through shares, where the investor is exposed to the exploration risk, and "senior" flow-through shares, where the investor is exposed to a combination of existing activity risk and exploration venture risk.

Finally, Kalymon comments on some future directions. The appeal of flow-through shares to senior companies can be expected to decline as these companies regain taxable status following the 1980-82 world recession. Thus, flow-through shares can be seen as providing equity financing incentives under conditions of poor profitability, and declining in use as industry conditions improve. Also, with growing exploration investment funds increasing the level of junior company exposure, investors will become increasingly more exposed to exploration risk. Given that the high volume interest in flow-through shares originated in the relatively safe exposure provided by senior company shares, the investor demand for the more speculative shares may decline. An evolving issue will be the marketability of the earned shares. If flow-through issues attract only short-term investors with high needs for liquidity, the flow-through share market cannot be self-sustaining. Moreover, depending on the perspective, the benefits of flow-through shares as neutralizing the advantage of taxable corporations in mining investment, relative to the junior company, may be outweighted by apparent cost to taxing authorities.

In discussion, Wil Barbour stressed that flow-through share provisions did not constitute simply a removal of tax but, instead, a postponement of tax. He emphasized that flow-through shares result in a transfer of risk from large senior company exploration to small junior company exploration. In his view, the history of mineral exploration in Canada has been that it is the small prospecting/exploration groups which find ore deposits, not the larger exploration organizations. I would only comment that this perception has not been born out in certain studies of the history of exploration successes.

Although the Open Discussion was subject to a time constraint, an interesting and useful dialogue developed on a very few topics not hitherto considered. These topics were:

- A comparison of gold selling practices in South Africa which are restricted by legislation, with those in North America and Australia which benefit from a free market for gold.

- The merits or otherwise of the gold mining industry integrating vertically into refining and/or fabrication such as into jewelry, a major market for gold. The consensus was that forward integration held no merit for the gold industry, although the industry should

endeavour to influence the jewelry business in, say, encouraging a movement toward high carat/low volume mark up production and sale.

- The practise of selling gold forward in the future market as a hedging or pre-pricing mechanism.

The discussion of each topic benefited greatly from the diverse but expert knowledge reposed in the various participants in the Workshop.

I would be remiss if I did not also acknowledge the contributions made to the Workshop by the three background studies made available (the first is included in the proceedings):

- Claudio Margueron's paper "The Gold Money Business in Brazil"
- Michael Doggett and Brian Mackenzie's paper "Canadian Gold Mining Trends: An Historical Perspective"
- Milling-Stanley, Green, "Gold 1986".[1]

In conclusion, I think the Centre for Resource Studies and the organizers of the Workshop deserve the congratulations of all of us, from the point of view of the specific topics chosen for formal presentation and discussion and for the diverse backgrounds of those invited to participate in the Workshop. This has resulted in a stimulating dialogue beneficial to most of us. In particular, the international perspective has been highly beneficial to Canadian participants in the Workshop.

In the Canadian context, from a domestic policy point of view, the dialogue has provided much in the way of hard information and informed perceptions for a resource industry which must operate in an international environment. In my judgment, the Workshop has eminently fulfilled its aims.

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1. George Milling-Stanley, Timothy Green; Consolidated Gold Fields PLC, May 1986, 72 pages.

APPENDIX I PROGRAM OF THE SEMINAR

17TH CRS POLICY DISCUSSION SEMINAR
LONG-TERM PROSPECTS FOR GOLD MINING

Monday, October 6

7:30 p.m.	Opening Comments
INTERNATIONAL OVERVIEW	Chairman: David Anderson
	A Gold Market Overview: Trends in Supply and Demand Speaker: Jeffrey Nichols Discussant: Brian Mackenzie

Tuesday, October 7

FUTURE GOLD MARKET CONDITIONS	Chairman: David Yudelman
8:30 a.m.	**The Demand for Gold** Speaker: Timothy Green Discussant: Donn Morgan
9:30 a.m.	**Mine Gold Supply to the Year 2000** Speaker: Jim Fisher Discussant: Hermann Enzer
11:00 a.m.	**Factors Which Affect Them and Their Impact on Gold** Speaker: Martin Murenbeeld Discussant: John Strongman
	Chairman: Brian Mackenzie
1:30 p.m.	**Gold Price Forecasting: Commodity and Monetary Perspectives** Speaker: Gerry Anders Discussant: Pat MacCulloch

2:30 p.m.	**Gold Exploration: Impact of Changing Geoscience Concepts and Technologies** Speaker: Roy Woodall Discussant: Bob Mason
4:00 p.m.	**Factors Affecting the Long-term Prospects of South Africa's Gold Production** Speaker: Danie Krige Discussant: David Yudelman

Wednesday, October 8

	Chairman: David Anderson
8:30 a.m.	Open Discussion

CANADA'S SUPPLY POSITION

9:30 a.m.	**Long-Term Break-Even Price for Canadian Gold Supply** Speakers: Donald Cranstone and Brian Mackenzie Discussant: Bob Hinds
11:00 a.m.	**Flow-Through Share Financing** Speaker: Basil Kalymon Discussant: Wil Barbour
1:30 p.m.	Small group assignments continue
	Chairman: Brian Mackenzie
2:15 p.m.	Small group reports and discussion
3:30 p.m.	**Concluding Overview** Speaker: Keith Buck

APPENDIX II SEMINAR PARTICIPANTS

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THE AUTHORS

Gerhard (Gerry) Anders, supervisor in the Metallic Minerals Section of the Ontario Ministry of Northern Development and Mines and the Ministry's Senior Policy Advisor, is experienced in analyzing and projecting international mineral market conditions for base metals, especially for nickel and gold. Dr. Anders' past experience includes, in the area of mine engineering, work for various mines in northern Ontario, Quebec, and the North West Territories and, in the area of economics, work for the Department of Indian Affairs and Northern Development. A graduate of West Germany's Technical University at Clausthal (M.Eng.) and of Texas A&M University (Ph.D. in Economics), Dr. Anders was also an assistant professor of economics at Eckerd College in Florida. He has written extensively in the field of mineral economics.

Keith Buck, Distinguished Visitor for the Centre for Resource Studies, is a graduate of McGill University and the University of Ottawa, where he studied mining engineering, geology, and economics. He joined Energy, Mines and Resources Canada in 1951, where he fostered a still-growing interest, both within and beyond the department, in the field of mineral economics. In 1973 he went to London as Counsellor for Minerals with the Canadian High Commission, and from 1977 to 1984, served as Secretary General of the International Lead and Zinc Study Group. In 1985 he was named Distinguished Lecturer by the Canadian Institute of Mining and Metallurgy.

Donald Cranstone, a mineral economist with the Mineral Policy Sector of the Department of Energy, Mines and Resources Canada, holds a B.Sc. and M.Sc. from the University of Manitoba and a Ph.D. from Harvard University. He is at present engaged in the analysis of mineral exploration in Canada. Dr. Cranstone has also been involved in resource appraisal, in the evaluation of mineral exploration economics and rates of ore discovery, and as a commodity specialist for gold, copper and other metals. His past experience includes work as a mine geologist and in geological mapping and research. His recent research, based on Canadian mining, has covered topics such as uranium and ore discovery rates and costs, the history of gold discoveries, and the importance of junior and senior companies in mineral discoveries. He has also researched world resources of complex sulphide ores.

Michael Doggett is a research associate of the Centre for Resource Studies at Queen's University. He holds a B.Sc. (honours) in geology from Mount Allison University and an M.Sc. in geology (mineral economics) from Queen's University. His background includes mineral exploration in Canada and Australia as well as extensive research into the economics of gold mining in Canada. Present interests and research focus on the costs and benefits associated with the global emphasis on exploration and development of gold deposits.

Jeremy (Jim) Fisher a graduate of Cambridge University, is now working with Brook Hunt & Associates Ltd., a firm conducting research into metal and mineral resources and markets. He joined the firm in 1986 on his retirement from Anglo American Corporation (AAC) of South Africa, where he was Head of Metal Studies - a position where he was leader of a team examining the cost structure and long-term future for different sectors of the world's mining industry with a view to guiding corporate exploration and acquisition strategy. Prior to working with AAC, Mr. Fisher was with Nchanga Consolidated Copper Mines. His experience there included the operation of major metallurgical plants and work as the Head of Research and Development and with the Consulting Metallurgists Office. In 1972, Mr. Fisher was seconded by NCCM to establish the School of Mines at Lusaka University and to serve as Head of the Metallurgy Department and as the school's Dean. Through work as manager of the Zambian mining industry technical services, he also provided back-up research and engineering services to the Zambian copper industry.

Timothy Green has been writing about gold for the last 20 years. His first book, The World of Gold, came out in 1968 and has since been revised many times. The latest version, The New World of Gold, was published in 1985. He has also written a book about diamond mining and marketing, The World of Diamonds. His next book will consider the prospects for gold to the end of this century. In addition to his work as an author, Mr. Green has worked as a consultant for the International Gold Corporation and is at present a consultant to Consolidated Gold Fields PLC, the London mining house. For his contribution to the company's annual gold market survey, he covers Europe, the Middle East, India, the Far East and Latin America - a task which involves visiting close to 40 countries each year for a first-hand look at their local gold markets.

Basil Kalymon is Professor at the University of Toronto's Faculty of Management Studies. His university degrees comprise a B.Sc from the University of Toronto and a M.Phil. and Ph.D. in administrative sciences from Yale University. A specialist in finance and management science, Dr. Kalymon has taught at the University of California, Los Angeles (UCLA) and at Harvard University as well as at the University of Toronto. He also worked one year for Currie, Coopers & Lybrand Ltd. as Manager-Finance Practice, and has, throughout his career, conducted consulting assignments for a large number of major companies. Dr. Kalymon has written extensively in the areas of finance (including mine and business financing), management science, economics, and the manufacturing industry.

Danie Krige, whose name is internationally associated with a widely-used ore valuation technique called "kriging", is known as the international authority on ore reserve evaluation. The first holder of the University of Witwatersrand's chair of mineral economics, Dr. Krige graduated from the South African University as a mining engineer (M.Sc. (Eng) and a D.Sc.(Eng)). He has participated in many international symposia, has lectured at universities throughout the world, and has published more than 50 technical papers on topics including mine and mineral economics and mining taxation. In addition to his university experience, Dr. Krige has also worked for Anglo Vaal, a mining finance group, as financial engineer and in the earlier days of his career worked for the Government Mining Engineer's Division of the South African government where he assisted in reporting on mining lease applications and in the original uranium negotiations with the UK and USA. Dr. Krige is the recipient of awards from the South African Institute for Mining and Metallurgy, the South African Academy of Science, and from the International Association for Mathematical Geology.

Brian Mackenzie is a senior research associate of the Centre for Resource Studies and a professor in the Department of Geological Sciences at Queen's University. He holds a B.Eng. (honours) in mining from McGill University, an M.Sc. in mineral economics from the University of the Witwatersrand, and a doctorate in engineering science (mineral economics) from Columbia University. After working as an engineer in mines in Canada and South Africa, he became an assistant inspector of mining leases for the South Afri-

can government, and later worked as a mineral economist with Energy, Mines and Resources Canada. Dr. Mackenzie joined McGill University in 1968 where he was responsible for teaching and research in mineral economics, and was director of the mining program until 1977. He joined Queen's University in 1978. In 1979 Dr. Mackenzie was named distinguished lecturer in mineral economics by the Canadian Institute of Mining and Metallurgy, and in 1983 he received their 'Robert Elver Mineral Economics Award'. He has presented mineral economics seminars in Canada, Australia, Brazil, Chile, China, Greece, Indonesia, South Africa, Sweden, Tanzania, and the United States.

Claudio Margueron is the founder of Claudio Margueron Consultoria Limitada, a management consulting and mineral economics firm in Rio de Janeiro, Brazil, which prepares studies for government and private multinational companies in Brazil. A professor of mineral economics, mining feasibility studies and quantitative methods for decision making at the Federal University of Rio de Janeiro, Dr. Margueron recently coordinated various studies related to the business aspects of Brazilian gold mining. He has also worked as senior mineral economist for the United Nations in New York City and as an executive director for Arthur D. Little Inc. with responsibility for the company's operations in Brazil. Dr. Margueron holds an engineer of mines degree from the Colorado School of Mines, a master's in mineral economics from Pennsylvania State University, and a doctorate in engineering science from the Henry Krumb School of Mines, Columbia University in New York.

Martin Murenbeeld is president and founder of M. Murenbeeld and Associates Inc., a firm which offers consulting services in the areas of foreign exchange, gold, and other matters related to the international financial environment. The firm's clients include a number of North America's largest gold producers. Dr. Murenbeeld graduated with an M.Sc. from the University of Alberta and with a Ph.D. in international finance from the University of California at Berkeley. His firm publishes reports including gold price and foreign exchange forecasts and economic and financial analysis. He has also held the post of assistant professor at the University of Toronto's Faculty of Management Studies, where he helped develop the international economics and finance curriculum.

Jeffrey Nichols is founder and president of American Precious Metals Advisors, Inc., a multi-faceted consulting and investment advisory firm serving the precious metals market. An internationally recognized expert on the economics of gold, silver, platinum and palladium, Mr. Nichols was Director of Precious Metals Research for Goldman, Sachs & Co. before founding his own firm. Mr. Nichols is also a member of the Metals Advisory Board of the New York Mercantile Exchange and serves on the Board of Directors of the American Stock Exchange's commodities subsidiary where gold contracts are traded. He is, in addition, an officer of the International Precious Metals Institute, an industry association of executives, traders, miners, refiners, academics, and government officials. Mr. Nichols began his career as an international economist at Citibank, where he specialized in foreign exchange markets and country risk assessment. He then served as Vice President and Chief Economist at Argus Research Corporation, an equity-oriented research and advisory firm.

Roy Woodall has been with Western Mining Corporation (WMC) in Australia since 1953, and their Director of Exploration since 1978. He graduated with a B.Sc. in geology from the University of Western Australia and an M.Sc. in mining from the University of California. Widely recognized for his scientific and professional contributions, Mr. Woodall is an Officer of the Order of Australia, and has received the William Smith Medal of the Geological Society of London, the Mawson Medal of the Australian Academy of Science, an honourary Doctor of Science from the University of Western Australia, the Mueller Medal from the Australian and New Zealand Association for the Advancement of Science, and the Institute Medal for 1984 from the Australasian Institute of Mining and Metallurgy. Mr. Woodall has presented more than 30 public lectures on mineral exploration, contributes to many associations and has authored numerous papers in the areas of geology and mineral exploration.

THE CENTRE FOR RESOURCE STUDIES

The Centre for Resource Studies (CRS) was established in 1973, under the sponsorship of Queen's University, the federal Department of Energy, Mines and Resources, and The Mining Association of Canada, to carry out a program of research and publication on mineral policy issues.

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